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Driver Behaviour by Vehicle Type:

Travelling Speed and Following Time

On a Four-Lane Divided Highway

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Executive Summary

This report examines the driver speed and following behaviour of vehicles travelling northbound on Highway 2 near Leduc during 1997. All regularly operated heavy vehicle configurations are permitted to travel on Highway 2 between Calgary and Edmonton, a four-lane divided highway.

Vehicles were classified into six categories based on length. The six categories, their respective length limits, and their proportion of traffic at the study location are as follows:

Length			Vehicle Category	Composition
3.5m	-	6.0m	Personal Vehicles	84.0%
6.0m	-	12.5m	Straight Trucks	4.4%
12.5m	-	25.0m	Truck-Trailer(s)	10.4%
25.0m	-	31.0m	Rocky Mountain Doubles	0.4%
31.0m	-	37.0m	Turnpike Doubles and Triples	0.8%
25.0m	*-*	*37.0m*	*All EEMVs (LCVs)*	*1.2%*

The last category "All Energy Efficient Motor Vehicles" (EEMVs) is a consolidation of the two previous categories; Rocky Mountain Double and Turnpike Double/Triple, which are permitted to operate on four-lane divided highways.

Two measures of driver behaviour were analyzed: adherence to speed limits and; adherence to safe following times (tailgating). Analysis of travelling speed showed that drivers of personal vehicles consistently (60%) exceeded the posted speed limit of 110 km/h, while commercial vehicle drivers on average drove at less than 110 km/h. Between 5% and 22% of commercial vehicle drivers exceeded 110 km/h (Appendix C). Within each vehicle size category, average speeds were relatively consistent over the different times of day, with the exception of Turnpike Doubles and Triples, which were driven at slower average speeds during the high traffic volume hours of 10:00h – 17:00h, than at other times of the day.

Analysis of following times (or "gap") revealed that as vehicle sizes increased, drivers followed the preceding vehicle at longer following times. The number of personal vehicle drivers that were following the preceding vehicle inappropriately outweighed the number of commercial vehicle drivers following too closely by approximately a 3:1 ratio. This is despite the fact that the recommended following time for personal vehicles is at least two seconds while it is four seconds or more for commercial vehicles, due to longer stopping distances.

EEMV (or Longer Combination Vehicle – LCV) drivers perform better than all other commercial vehicle drivers at maintaining at least a four second gap from the preceding vehicle. The larger the vehicle, the more likely its driver is to adhere to safe operating practices.

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EEMV (or Longer Combination Vehicle – LCV) drivers perform better than all other commercial vehicle drivers at maintaining at least a four second gap from the preceding vehicle. The larger the vehicle, the more likely its driver is to adhere to safe operating practices.

The key driver behaviour findings of this report, based on one year's survey are:

General:

- The larger the vehicle, the slower it is driven.
- The larger the vehicle, the greater the amount of time at which its driver follows the preceding vehicle.
- As traffic volumes increase, the proportion of drivers following too closely increases for all vehicle types.
- As traffic volumes increase, average following times decrease for all vehicle types. There is a very strong negative relationship between total traffic volume and average following time (correlation coefficient between -0.959 and -0.999).

Personal Vehicles:

- The majority of personal vehicle drivers drive at speeds exceeding the posted speed limit (average: 114 km/h; posted speed limit: 110 km/h).
- The total number of personal vehicle drivers following inappropriately outweighs the number of commercial drivers following too closely by a ratio of 3:1.
- As traffic volumes increase, personal vehicle speed also increases. There is a very strong positive relationship (0.973 correlation coefficient) between total traffic volume and personal vehicle average speed.

Commercial Vehicles:

- All truck types are driven, on average, below the posted speed limit (average: 103 – 106 km/h; posted speed limit: 110 km/h).
- As truck sizes increase, fewer drivers exceed the posted speed limit.
- As truck sizes increase, fewer drivers follow the preceding vehicle at less than four seconds.
- Commercial vehicles make up over 50% of traffic during early morning hours between 02:00h – 05:00h, yet they constitute only 16% of total 24-hour traffic volumes.
- As traffic volumes increase, commercial vehicle speeds also increase, but to a much lesser degree than that observed for personal vehicles (correlation coefficient between 0.319 and 0.859).

EEMVs:

- EEMV drivers consistently travel at speeds below the posted speed limit, averaging 103 km/h, but in excess of the 100 km/h EEMV speed limit.
- EEMVs are operated during times that minimize their impact on, and interaction with, other vehicles (even though this practice is not a condition of the EEMV operating permit).
- EEMV drivers exhibit the best following behaviour of all commercial vehicles, with the smallest proportion following the preceding vehicle at less than four seconds.

Overall, as vehicle sizes increase, the more likely its driver is to adhere to safe operating practices respecting speed and following times.

Traffic volumes greatly influence average speeds and following times for drivers of all vehicle types. As volumes increase, average following times decrease for all vehicle types. Increased average speeds were also observed with increased total traffic volumes. However, commercial vehicle drivers do not increase their speed as much as personal vehicle drivers when traffic volumes grow.

The results of the analysis clearly support the hypothesis posed for this study: **"Drivers of larger vehicles travel slower and at greater following times than drivers of smaller vehicles".**

There are two major factors contributing to the higher safety performance of EEMV drivers in Alberta:

- the "*Conditions Governing the Operation of Energy Efficient Motor Vehicles in Alberta*" permit, administered by Alberta Infrastructure, Transport Engineering Branch, and;
- voluntary corporate and driver operating practices demonstrated by EEMV operators in Alberta

The EEMV permit is probably the largest contributor to the safe operation of EEMVs in Alberta. The conditions imposed upon EEMV operators (included in Appendix A), are all designed to improve the safe operation of these longer truck combinations. These conditions are comprehensive, covering all aspects of EEMV operations, including:

- information reporting requirements;
- restricted routes over which EEMVs are allowed to operate;
- restricted times and days during which EEMVs are not permitted to operate;
- minimum equipment specifications;
- maximum equipment sizes and weights for each EEMV type;
- specific driver instructor qualifications;
- minimum driver qualifications, training and experience;
- a copy of the drivers abstract showing "*no driving-related criminal code convictions in the prior 36 months; no more than 2 moving violations in the prior 12 months; and no more than 3 moving violations in the prior 36 months*".

The last condition listed above, of all the permit conditions, is probably the highest contributor to EEMV safety. This is because the absence of driving-related criminal code convictions and moving violations indicates general, overall safe driving behaviour for that particular driver. Ultimately, it is the EEMV driver who is responsible for the safe operation of the vehicle, including speed, following time, interaction with other traffic, and ensuring that all equipment is functioning properly.

Voluntary corporate and driver operating practices increase the safe operation of EEMVs by generally travelling in off-peak hours, minimizing interaction with other traffic that travels primarily during the day time.

Further, there are also financial incentives for the safe operation of EEMVs. Travelling at slower speeds and longer following times reduces the risk to the EEMV vehicle itself (which can cost upwards of a quarter million dollars). Also, fuel consumption operating costs are minimized when drivers do not travel at high speeds, particularly in excess of 100 km/h.

Given that other, smaller commercial vehicles also represent a sizeable investment, and that their fuel costs would also increase at high speeds, it can be concluded that the conditions imposed by the EEMV permit contribute the most to the higher safety levels of EEMV drivers over smaller commercial truck drivers.

This study does not indicate that EEMVs are driven less safely. To the contrary, the results demonstrate that EEMVs are driven in a safer manner than smaller commercial vehicles.

1. Introduction

The Alberta economy has been expanding significantly in recent years, generating increased trade volumes, both nationally (east-west) and internationally (north-south). The advent of free trade agreements has driven business and government to compete on a continental and global scale, resulting in increased competitive pressures. Efforts to increase the efficiency of goods transport have permitted products to be marketed less expensively, and allowed Alberta producers and exporters to remain competitive, and expand their market bases. Consumers and importers also benefit through lower prices for imported goods.

A very visible development in accomplishing transport efficiencies has been the use of larger commercial trucks. These truck-trailer combinations called Energy Efficient Motor Vehicles (EEMVs), or Longer Combination Vehicles (LCVs), have been approved for operation in Alberta for the past thirty years. More recently, allowable heavy truck weights have been increased on all highways, but longer EEMVs are restricted to travelling on four-lane divided highways for safety concerns.

As vehicles are getting longer and heavier to meet the needs of a growing economy, for safety reasons it is important that highway administrators understand the vehicle operator behaviour for different-sized vehicles. A review of the literature indicated that there are few studies and little is known about driver behaviour by vehicle type. Thus, the following primary research was undertaken to determine the adherence to posted speeds and recommended following times between vehicles.

Driver behaviour is a major factor affecting highway safety. Examples of detrimental actions are speeding, tailgating, unsafe lane changes and travelling in another driver's blind spot. This report focuses on driver speed and following behaviour of vehicles travelling northbound on Highway 2 south of Edmonton near Leduc. Highway 2 between Calgary and Edmonton is the major economic spine of Alberta's highway system with the province's highest traffic volumes. This location was also chosen because all EEMV (LCV) configurations are permitted to use this route.

The Transportation Policy and Economic Analysis Section of Alberta Infrastructure is currently carrying out a comprehensive study of EEMVs/LCVs in Alberta, entitled "*The Effects of Energy Efficient Motor Vehicles in Alberta*", examining safety, economic productivity, and truck-rail intermodal competition issues relating to these large truck combinations. This report is intended to complement the findings of the EEMV study, to give a "more complete picture" through the examination of characteristics of drivers of vehicles of different lengths.

This report is organized in five sections. The first second section provides a description of the study. The second section details background information necessary to establish the context of the study. The following section carries out the analysis of the information gathered. The fourth section provides discussion of, and

conclusions based on the analysis results. Finally, a number of appendices complete this report, providing additional details on data collection and the analyses undertaken.

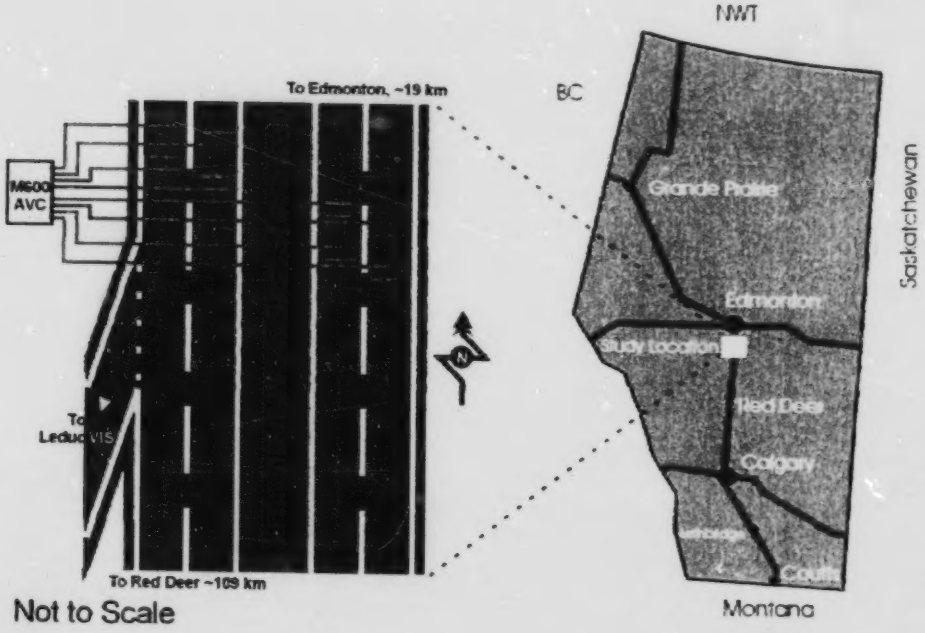
2. Background

This section describes the study location, types of equipment used, study methodology, and the data collected.

2.1. Study Location

Traffic measurement was carried out on Highway 2, Control Section 30, Kilometre 32. This section of highway is divided, with four lanes. This location is approximately 19 kilometres south of the Edmonton south city limits, and about 109 kilometres north of the Highway 11A junction at Red Deer. There are electronic loops located in each lane, immediately north of the entrance to the Leduc Vehicle Inspection Station (VIS), to record vehicle speed and length, as shown in the following diagram.

Figure 2.1. Study Location



Not to Scale

2.2. Equipment

A Golden River Marksman 600 automated vehicle classifier (AVC) was connected to the traffic counting loops to record individual vehicle lengths and operating descriptors. Alberta Infrastructure contracted out the installation,

operation, maintenance and data collection tasks for this AVC to a private firm.

The classifier recorded the date, time, lane, direction, gap, headway, and length of each vehicle (in centimetres), as it was travelling at the study location. Gap and headway are measures of following time, or distance between vehicles. Headway measures the amount of time from the front of the first vehicle to the front of the following vehicle, while gap measures the amount of time from the rear of the first vehicle to the front of the following vehicle. The contractor also added a day/night indicator (D/N) to each record based on the average sunrise and sunset times for each month. Typical data provided by the contractor are shown in the table below.

Table 2.2. Automatic Vehicle Classifier Data

Veh	Date	Time	L	D	Gap	Headway	Speed	Length	RC	D/N
00011	27 Nov 96	13:05:33	4	0	65.9	66.0	120	458	0	1
00012	27 Nov 96	13:05:33	3	0	31.7	31.9	111	21597	0	1
00013	27 Nov 96	13:05:35	2	0	23.6	24.2	116	531	0	1
00015	27 Nov 96	13:05:44	1	0	24.1	24.2	104	2377	0	1
00016	27 Nov 96	13:05:56	1	0	11.1	11.9	101	413	0	1
00017	27 Nov 96	13:06:03	1	0	6.7	6.8	108	339	0	1
00018	27 Nov 96	13:06:28	1	0	25.0	25.1	111	2065	0	1

2.3. Methodology

As shown by Figure 2.1 above, traffic collection loops are installed under all four lanes (both directions) of the highway. Since the traffic collection loops in the southbound lanes are very near the entrance to the VIS, the detailed operational information for northbound traffic only was examined. If southbound traffic were examined at this location, an inaccurate representation of the travelling characteristics of commercial vehicles (over 4,500 kg GVW) would be depicted. This is due to the fact that many of these "heavy" vehicles would be decelerating when crossing the loops in preparation to enter the Leduc VIS. Thus, northbound lanes only are analyzed to represent typical driver behaviour on a four-lane divided highway.

Data collection was carried out from November 27, 1996 to April 1, 1998. In order to account for seasonal fluctuations in traffic patterns, only the data for the 1997 calendar year was examined, January 1, 1997 to December 31, 1997.

During the 1997 year, the AVC was inoperative approximately 1,100 hours, which results in an effective sample rate of 87%. This is a very high sample rate, and as such, the results should be highly indicative of driver behaviour for the total population.

Table 2.3. Automatic Vehicle Classifier Down Time

From		To		Hours
97/01/09	05:15	97/01/09	13:59	8.73
97/01/10	06:53	97/01/10	11:22	4.48
97/01/18	13:08	97/01/18	16:48	3.67
97/01/19	16:31	97/01/25	15:24	142.88
97/01/26	14:51	97/02/01	14:01	143.17
97/02/01	18:09	97/02/08	13:28	163.32
97/02/10	00:14	97/02/12	16:19	64.08
97/03/29	00:08	97/03/29	08:01	7.88
97/04/17	18:01	97/04/18	00:02	6.02
97/04/25	00:00	97/04/25	13:01	13.02
97/05/22	00:34	97/05/22	23:19	22.75
97/05/30	18:02	97/05/30	22:27	4.42
97/07/03	00:35	97/07/03	08:35	8.00
97/08/23	00:16	97/08/27	21:40	117.40
97/10/24	17:53	97/10/25	20:51	26.97
97/10/26	00:04	97/10/26	17:43	17.65
97/10/27	06:32	97/10/30	21:52	87.33
97/11/15	00:31	97/11/27	11:53	299.37
Total Hours Out of Operation:				1,141.13
Amount of Time in Operation:				**86.97%**

A total of 2,537,045 vehicles were included in the northbound data set for the 1997 calendar year. In order to compare travelling characteristics across different vehicle types, each record was grouped into one of the following categories based on vehicle length, measured in metres:

3.5m	-	6.0m	Personal Vehicles
6.0m	-	12.5m	Straight Trucks
12.5m	-	25.0m	Truck-Trailer(s)
25.0m	-	31.0m	Rocky Mountain Doubles
31.0m	-	37.0m	Turnpike Double/Triple Trailers

An additional category was created by combining the last two (25.0m – 37.0m), to define the travelling characteristics for all EEMV vehicles which are travelling on Highway 2.

The raw data collected from the AVC for the 1997 calendar year was imported into a Microsoft Access database to define tables of records for each vehicle length category. This information was then translated to a Microsoft Excel spreadsheet for statistical analysis, using the data analysis functionality provided by the software. The results of this statistical analysis are presented in the "Analysis" section.

2.4. Data Description

In order to facilitate an understanding of this report, the data collection methodology is evaluated. The following sections describe the overall reliability of the sample to the entire travelling population, sampling error, measurement error when recording vehicle length and speed, defining vehicle length categories, and seasonal fluctuations of traffic volumes.

2.4.1. Sample Size

Since the sample period encompassed an entire year, it is reasonable to assume that an accurate representation of two-way traffic could be gained from examining northbound traffic only.

Reports provided by the contractor show that the AVC was in operation for 87% of the time throughout 1997, and recorded a total of 2,537,048 vehicles northbound and 2,396,106 vehicles southbound (51% north and 49% south). Also, information provided by the former Alberta Transportation and Utilities department[1] shows that average annual two-way daily traffic for this location is 16,646 vehicles per day. Assuming equal distribution of traffic volumes between northbound and southbound vehicles would result in an average daily traffic volume of 8,323 vehicles in each direction. This figure results in a total traffic volume of 3,037,895 vehicles for the entire year, in the northbound direction only. As stated earlier, a total of 2,537,045 vehicles were included in the data set for analysis of travelling characteristics. This method results in a sample rate of 83.5%, a relatively large sampling of driver behaviour.

2.4.2. Sampling Error

Statistical publications were consulted to determine a measure of the reliability of the sample, as it would relate to the entire travelling population at the study location[2]. Given that the sample size is 2.5 million, while the population size is 3 million, at a 95% confidence level, the sample's reliability is ±0.025% (much less than 1%). At a 99% confidence level, reliability is calculated at ±0.033%. The extremely low sampling error inherent in the data means very accurate statistical descriptors and that even small differences can be statistically significant.

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1 Alberta Transportation and Utilities, Highway Network Planning Section; Alberta Primary Highway Traffic Volume, Vehicle Classification, Travel and ESAL Report 1997. March 19, 1998; p. 3

2 Arkin, Herbert & Colton, Raymond; Tables for Statisticians, 2nd Edition. Barnes & Noble, Inc. 1963; p. 145

2.4.3. Measurement Error - Vehicle Length

Information provided by the AVC manufacturer states that vehicle length is judged to be accurate to a level of plus or minus 10 percent (±10%). This error only affects categorization of vehicles, and ±10% is acceptable for this purpose. Data were categorized taking into account confidence bands around allowable lengths to accommodate the variation in length estimate.

2.4.4. Measurement Error - Vehicle Speed

The measurement of a vehicle's speed, based on the AVC manufacturer's specifications, is accurate to ±5%. Given the extremely large sample size, this source of error should not be a major consideration. Furthermore, this research is more concerned with the relative comparisons of different vehicle size groupings than with absolute speeds; that is, do large vehicles travel faster or slower and closer or further behind than other vehicles.

2.4.5. Vehicle Length Categories

The data were aggregated into the following categories, as defined by length of vehicle:

- Personal Vehicles (cars, pickups, vans) (3.5m – 6.0m)
- Straight Trucks (2-3 axles, buses) (6.0m – 12.5m)
- Truck-Trailer(s) (semis, two trailers) (12.5m – 25.0m)
- Rocky Mountain Doubles (25.0m – 31.0m)
- Turnpike Doubles & Triple Trailers (31.0m – 37.0m)
- All Energy Efficient Motor Vehicles (25.0m – 37.0m)

An explanation of the rationale behind defining these categories follows.

2.4.5.1. Personal Vehicles

Most jurisdictions assign a measurement of 6.0 metres as the upper limit for personal vehicles. This limit would include cars, pickup trucks, vans, etc. There are very few personal vehicles in operation in Alberta that would be longer than 6.0 metres (i.e. some large recreational vehicles). In determining the lower bound for this category, the overall length measurements for small compact cars were investigated. While a lower limit of 3.5 metres would exclude motorcycles from the analysis, including anything smaller than this may yield erroneous results. For example, one indicator of traffic counter malfunction is the reporting of a high number of motorcycles. Thus, it was assumed that

it would be reasonable to carry out the analysis for personal vehicles between 3.5 and 6.0 metres in length, excluding all vehicles measured at less than 3.5 metres.

2.4.5.2. Straight Trucks

In defining the bounds for this category, Alberta Legal Weights and Dimensions regulations were reviewed. The maximum length for straight trucks in Alberta is 12.5 metres[3]. Thus, the limits for this category are defined as 6.0 metres to 12.5 metres.

2.4.5.3. Truck-Trailer(s)

Based on Alberta Legal Weights and Dimensions regulations, the maximum length for a truck or tractor with a single trailer combination is 23 metres[4]. For twin trailer combinations, the maximum length allowable in Alberta is 25 metres[5]. Length alone will not decisively identify which vehicle could be a tractor-single trailer unit, or a tractor-2 trailer combination. A more sophisticated vehicle classifier that could examine axle compositions and inter-axle spacing, or, manual visual classification would be required. Since it is possible that the overall length of a twin trailer combination could be less than 23 metres, and there is a great deal of difficulty in defining each particular vehicle configuration, this category is defined in terms of a "larger" commercial vehicle, with a length between 12.5 metres and 25.0 metres.

2.4.5.4. Rocky Mountain Doubles

Alberta allows the regular operation of over-length commercial vehicles (longer than 25 metres), under a permit system. Commercial operators must satisfy equipment, safety and driver requirements in order to obtain a permit to operate a Rocky Mountain Double, for which a fee is paid annually. These Energy Efficient Motor Vehicles (EEMVs), as they are called in Alberta, or Longer Combination Vehicles (LCVs), have been travelling Alberta highways for over thirty years. The operation of Rocky Mountain Doubles is permitted on all four lane divided highways, as well as selected approved two lane undivided routes[6].

A Rocky Mountain Double consists of two trailers, one longer and one shorter. Usually the longer trailer is in the range of 12.2 metres to

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3 Alberta Infrastructure, Transport Engineering; Legal Weights & Dimensions. http://www.tu.gov.ab.ca/Wgt_Dimen/teq001.htm, February 17, 2000

4 Ibid.

5 Ibid.

6 Alberta Infrastructure, Transport Engineering; Conditions Governing the Operation of Energy Efficient Motor Vehicles in Alberta. October 20, 1999.

16.2 metres (40-53 feet) in length, while the shorter trailer is between 7.3 and 8.5 metres (24-28 feet). Usually the larger trailer is placed in front of the shorter trailer. However, in certain situations where the shorter trailer weighs heavier than the longer trailer, the shorter trailer would be placed in front of the longer trailer, sometimes called a "Reverse Rocky" configuration.

In defining the length limit for this category, the permit that governs the operation of Rocky Mountain Doubles in Alberta was reviewed. Maximum length limit in Alberta for this configuration is 31 metres.[7] Thus, this category is defined as those vehicles having a length between 25 metres and 31 metres.

2.4.5.5. Turnpike Doubles & Triple Trailers

Turnpike Doubles and Triple Trailer combinations are the longest vehicles regularly permitted to operate on Alberta highways. They are allowed to operate on all four lane divided highway segments, as well as Highway 1A between Calgary and Highway 1, and Highway 11A between Highway 2 and Gaetz Avenue, Red Deer. Turnpike Doubles consist of two trailers of at least 12.2 metres (40 feet) in length, with an overall length no longer than 37 metres[8]. Triple Trailer combinations have three trailers, usually between 7.3 and 8.5 metres (24-28 feet) long, with a maximum length limit of 35 metres[9].

Although it is clear that these two longer vehicle configurations are quite different, they were "combined together" for this category as it would be very difficult to distinguish between a Turnpike Double and Triple Trailer combination based on length alone. This is because there is a possibility of having a Turnpike Double with a length of less than 35 metres. It would be unclear as to whether a particular vehicle is a Turnpike Double or a Triple. Turnpike and Triple configurations are both allowed on the same routes throughout the province. Therefore, these two configurations are included in this category with a length limit ranging from 31 metres to 37 metres.

2.4.5.6. All Energy Efficient Motor Vehicles

This category is a consolidation of the previous two over-length vehicle groups (25 – 37m). Analysis of the travelling characteristics of this group would present an "overall" view of the speeds and following times for these highly visible, longer vehicles. It is also important to note that although these vehicles are longer, they are not heavier.

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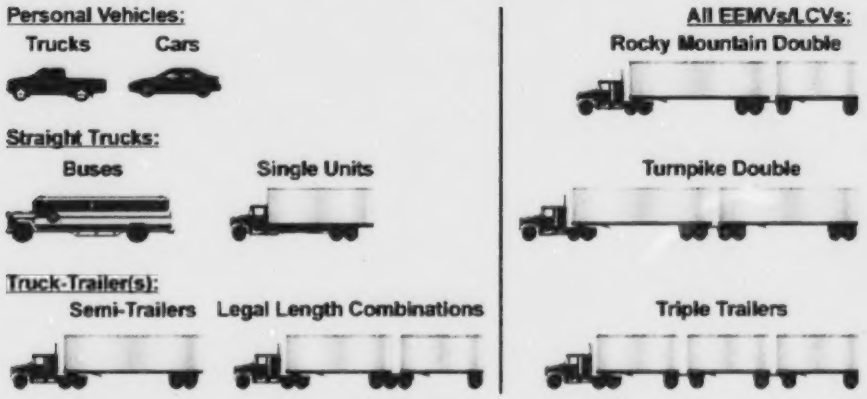
7 Ibid. p. 6
8 Ibid. p. 8
9 Ibid. p. 7

Maximum gross vehicle weight limits for EEMVs are the same as for other commercial vehicles (62,500 kg).

A comprehensive permit program covers the firms and drivers that operate EEMVs in Alberta. All aspects of operation are covered, including routes, hours of operation (near Edmonton and Calgary only), weather, driver qualification, training, and equipment. A complete copy of the permit governing the use of EEMVs in Alberta is included in Appendix A.

An illustration of typical vehicles for the purposes of this study is shown below in Figure 2.4.5.

Figure 2.4.5 Vehicle Configurations



2.4.6. Seasonal Traffic Volume Fluctuations

The vehicle classification traffic survey was carried out from November 27, 1996 to April 1, 1998. Analysis of the entire sample would give results that may be skewed by winter travel patterns, since the survey period encompasses two winters, but only one summer. To accurately reflect average operating conditions, a twelve-month period is used as the basis for analysis – January 1, 1997 to December 31, 1997.

3. Analysis

This section details the data analyses that were carried out in examining the speed and following characteristics of the six different vehicle length categories. These categories were defined earlier in section 2.4.5 above.

Given that larger commercial vehicles are driven by professional drivers, are heavier, and take longer to stop than smaller personal vehicles, the research hypothesis posed for this study is:

> **"Drivers of larger vehicles travel slower and at greater following times than drivers of smaller vehicles."**

First, overall traffic composition is defined for the 1997 year. Next, statistics for speed are examined, followed by the statistical measures for following time. Time-of-day traffic volume variations for all vehicle types are then presented. Then, advanced statistical analysis is undertaken to examine whether each of the groups is statistically significant. That is, whether the statistical results reveal that each of these groups is actually different from all others. Finally, the effects that different traffic volumes have on driver behaviour respecting speed and following time are presented. The preliminary statistical data outputs are included in Appendix B. Statistical analysis results, including distribution charts for each vehicle class, are presented in Appendix C.

3.1. Traffic Composition

Based upon the length parameters established earlier for the six vehicle length categories, total vehicles by type observed on Highway 2 northbound at Leduc are as follows in Table 3.1 below.

Table 3.1. Traffic Composition by Vehicle Type

Vehicle Type	Length	Number	%
Personal Vehicles	3.5m–6.0m	2,130,314	84.0%
Straight Trucks	6.0m – 12.5m	113,085	4.4%
Truck/Trailer(s)	12.5m – 25.0m	263,659	10.4%
Rocky Mtn. Doubles	25.0m – 31.0m	9,729	0.4%
Turnpike/Triples	31.0m – 37.0m	20,258	0.8%
Total		2,537,045	100.0%

All EEMVs	25.0m – 37.0m	29,987	1.2%

At this location, personal vehicles constitute 84% of the traffic mix, which is typical for Alberta Primary Highways. In 1997, personal vehicles (non-

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All EEMVs	25.0m – 37.0m	29,987	1.2%

At this location, personal vehicles constitute 84% of the traffic mix, which is typical for Alberta Primary Highways. In 1997, personal vehicles (non-

commercial) accounted for 84.6% of the traffic mix across the Province[10]. As well, all Energy Efficient Motor Vehicles (Rocky Mountain Doubles, Turnpike Doubles, and Triple Trailers), constitute only 1.2% of the total traffic mix (i.e., one in one hundred vehicles travelling at this location is an EEMV). This is despite the fact that this location is within the most heavily travelled section of highway in the Province, and allows all configurations of EEMVs to operate. Even with growing use of EEMVs in the province of Alberta, they still constitute a very small portion of traffic volumes (1.2%).

3.2. Speed

Statistical descriptors presented are average, median (value at which 50% of the vehicles are travelling slower, and 50% are travelling faster), mode (most frequently occurring value), standard deviation, variance, (measures of dispersion of the data), and the portion of the traffic which is speeding.

The following table presents basic statistical measures for speed for each of the vehicle length groups.

Table 3.2. Speed Statistics

Group	Personal Vehicles	Straight Truck	Truck Trailer(s)	Rocky Mtn. Doubles	Turnpike/ Triple	All EEMVs
Length	3.5-6.0m	6.0-12.5m	12.5-25.0m	25.0-31.0m	31.0-37.0m	25.0-37.0m
# Vehicles	2,130,314	113,085	263,659	9,729	20,258	20,987
Speed (km/h):						
Average	114.1	105.4	105.5	104.2	102.9	103.3
Median	114	106	106	104	103	104
Mode	114	109	109	104	104	104
85th %ile	122	115	113	112	109	110
Std. Dev.	8.2	9.4	7.9	8.3	6.4	7.1
Variance	67.5	89.2	62.1	69.6	40.9	50.6
% Speeding:						
> 110 km/h	60.4%	22.1%	17.9%	14.5%	4.7%	7.9%
* > 100 km/h	N/A	N/A	N/A	59.7%	54.9%	56.5%

* An examination of vehicles travelling over 100 km/h was undertaken for vehicles longer than 25 metres only, due to the condition of the operating permit restricting speeds for these vehicles to the lesser of 100 km/h or the posted speed limit.

This table shows that, in general, the average, as well as the median, mode and 85th percentile speeds decline with increased vehicle sizes. The 85th percentile speed (speed at which 85% of the population travels at, or less than) was calculated, as this is a measure that contributes to the establishment of an "appropriate" speed limit. The following figures give graphical representations of the distribution of speeds by vehicle type. These clearly shows that the distributions of vehicle speeds at Leduc are two-tailed,

[10] Alberta Transportation and Utilities, Highway Network Planning Section; Alberta Primary Highway Traffic Volume, Vehicle Classification, Travel and ESAL Report 1997. March 19, 1998; p. 34

that is, distributed normally about the mean with little skew and pronounced peaking.

Figure 3.2A. Personal Vehicle Travelling Speeds

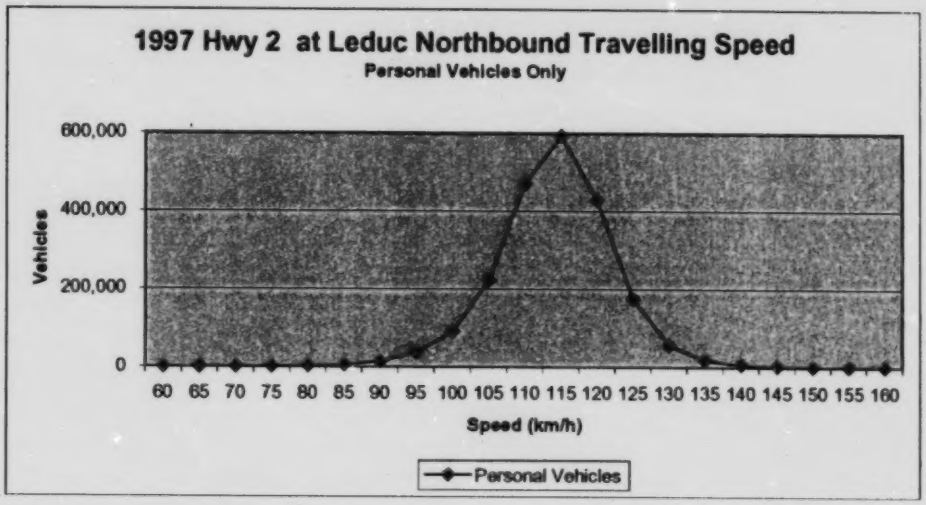

1997 Hwy 2 at Leduc Northbound Travelling Speed
Personal Vehicles Only
600,000
400,000
200,000
0
Vehicles
60 65 70 75 80 85 90 95 100 105 110 115 120 125 130 135 140 145 150 155 160
Speed (km/h)
Personal Vehicles

Figure 3.2B. Legal Length Commercial Vehicle Travelling Speeds

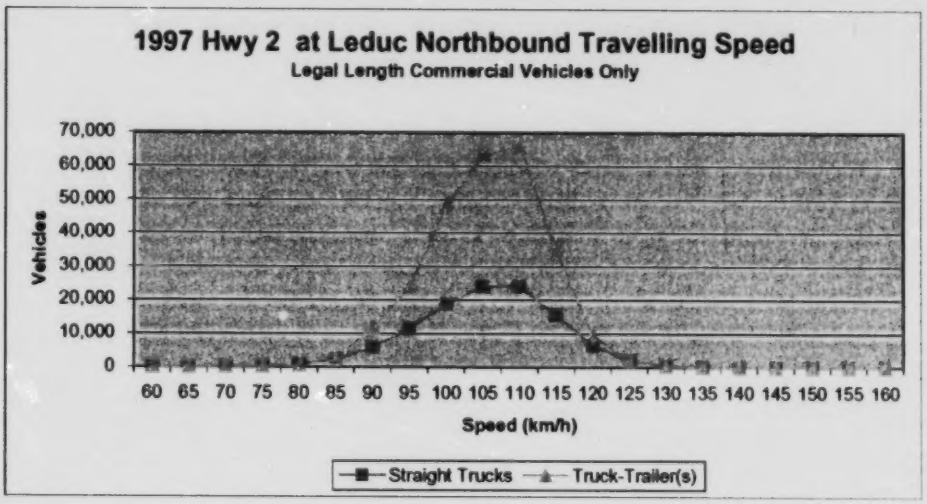
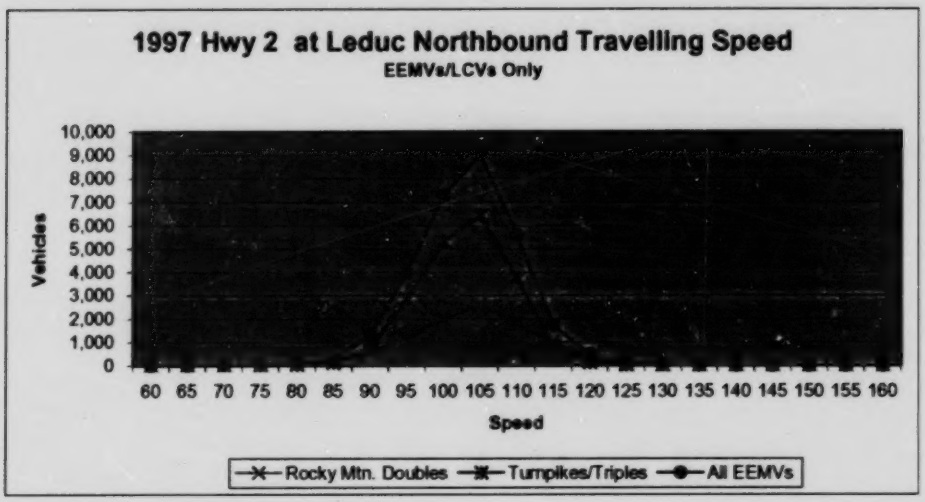


Figure 3.2C. EEMV/LCV Travelling Speeds



3.3. Following Time

Following time reflects the possibility of tailgating. Drivers following the preceding vehicle at smaller elapsed times are more likely to be tailgating than drivers following at longer elapsed times.

In Alberta, it is recommended to follow a preceding vehicle by at least two seconds for personal vehicles[11], and at least four seconds for commercial vehicles[12] in normal driving conditions. When conditions are adverse (weather, light, etc.), it is recommended to increase these following times. This method allows for a longer following distance when travelling at higher speeds, as is appropriate.

Table 3.3 presents basic statistical measures for following time for drivers of each of the vehicle groups.

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[11] Alberta Infrastructure, Driver Safety and Research; Basic License Driver's Handbook. http://www.tu.gov.ab.ca/Driv_Man/frontcov.htm, February 23, 2000.

[12] Alberta Infrastructure, Driver Safety and Research; Operator's License Information For Driving as a Profession, August 1999.

Table 3.3. Following Time Statistics

Group	Personal Vehicles	Straight Trucks	Truck-Trailer(s)	Rocky Mtn. Doubles	Turnpikes/ Triples	All EEMVs
Veh. Length	3.5-6.0m	6.0-12.5m	12.5-25.0m	25.0-31.0m	31.0-37.0m	25.0-37.0m
# Vehicles	2,130,314	113,085	263,659	9,729	20,258	29,987
Time (sec)						
Average	13.2	11.9	14.4	17.6	22.6	21.0
Median	7.6	7.2	8.7	10.5	14.0	12.6
Mode	1.4	1.9	2.2	2.4	3.1	3.1
Std. Dev.	15.8	9.4	16.3	19.0	22.5	21.6
Variance	250.7	89.0	266.7	360.6	506.7	464.9
% Following:						
≤ 2 seconds*	13.8%	N/A	N/A	N/A	N/A	N/A
≤ 4 seconds*	N/A	29.1%	23.4%	18.6%	14.6%	15.9%

* Following times as recommended by public literature published by Alberta Infrastructure Driver Safety and Research.

This table shows that, in general, larger vehicle drivers tend to follow the preceding vehicle at longer distances (and times), than do drivers of smaller vehicles. With the exception of straight trucks, as vehicle sizes increase, the average following time also increases. Figures 3.3A - 3.3C below give graphical representations of the distribution of following times by vehicle type.

Figure 3.3A. Personal Vehicle Following Times

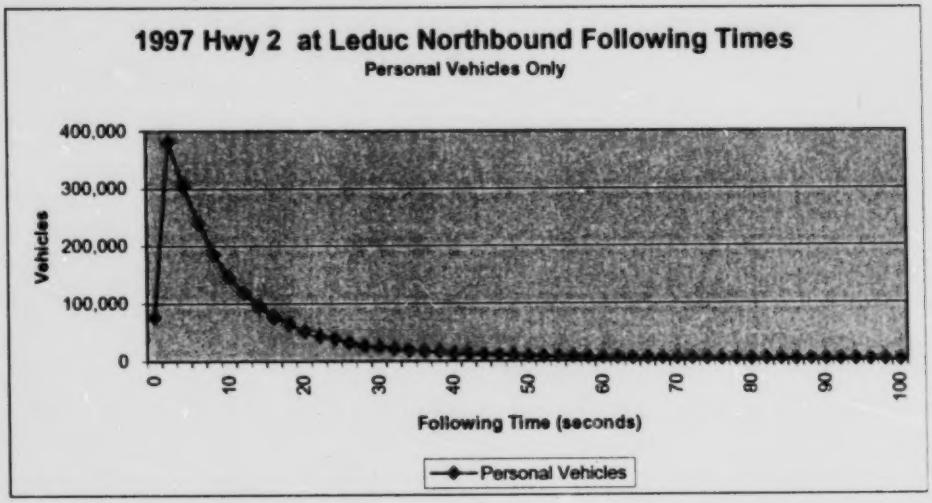


Figure 3.3B. Legal Length Commercial Vehicle Following Times

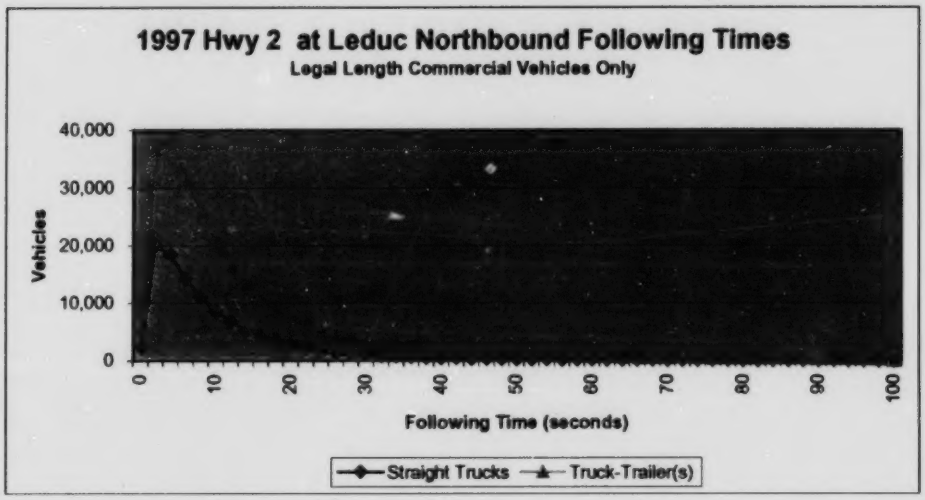
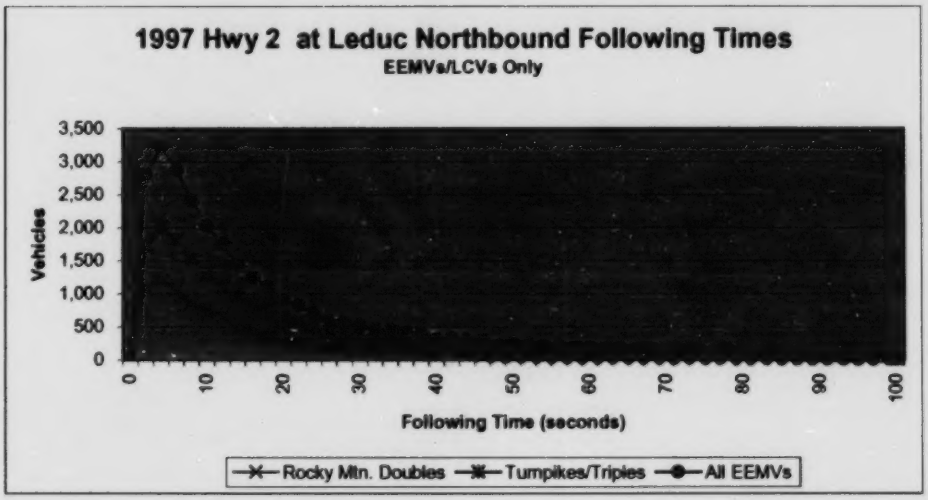


Figure 3.3C. EEMV Following Times



The charts above show that the distribution of following times for all vehicle types is clearly one-tailed in nature, skewed to the right (i.e. peaking at the left of the range with gradual sloping to the right).

3.4. Time of Day Variations

In order to complement our understanding of driver behaviour, analysis of speeds and following times was undertaken on a time-of-day basis. As

personal vehicles make up 84% of the study vehicles, driver behaviour of other vehicle types is likely influenced by the behaviour of personal vehicle drivers. Thus, for each vehicle category, average speed and following times were examined for one-hour segments of all days of the survey period.

3.4.1. Traffic Volumes

In order to more fully understand driver following time behaviour, further analysis was undertaken. It was proposed that the level of service that a portion of road provides might affect following time behaviour. Level of service is an indication of the amount of congestion being experienced on a particular section of roadway. As level of service goes down (from A to F), the amount of congestion increases. An illustration of the different levels of service is included in Appendix D. The traffic composition at the survey location was defined earlier in Table 3.1. Using this information, the different hourly traffic volumes that translate to Levels of Service measures are as follows in Table 3.4.1 below[13].

Table 3.4.1A. Level of Service Traffic Volumes

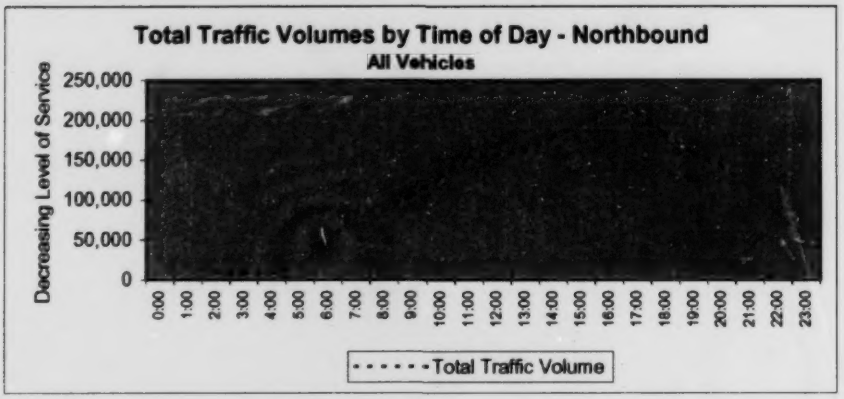
Level of Service	Hourly Traffic Volume
Level of Service A	< 1,275
Level of Service B	1,275 – 2,041
Level of Service C	2,042 – 3,061
Level of Service D	3,062 – 4,081
Level of Service E	4,082 – 4,681
Level of Service F	> 4,681

Within a given section of road, as traffic volumes increase, vehicles travel closer together, sometimes accompanied by speed reductions.

An examination of the hourly traffic volumes throughout the year indicates that a Level of Service "A" is provided on average, with average hourly volumes ranging from 26 vehicles per hour to 661 vehicles per hour. This portion of Highway 2 experiences only slight reductions in Level of Service from "A" to at worst, "B", based on observed traffic composition and volumes. An illustration of the total traffic volumes across the 1997 year is shown in Figure 3.4.1A.

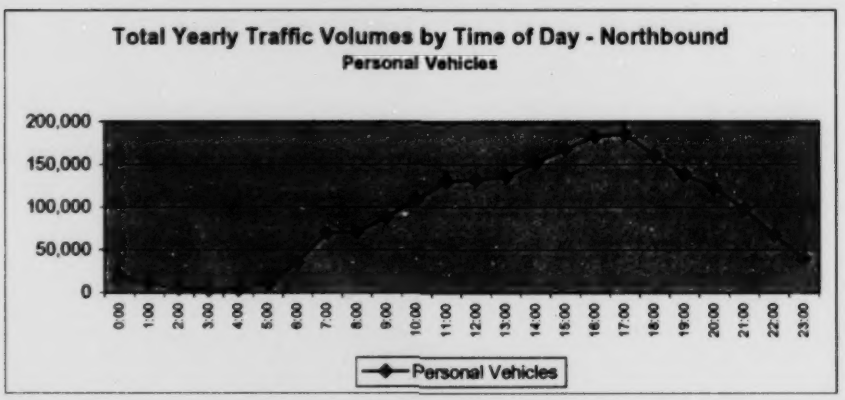
[13] Alberta Infrastructure, Highway Asset Management Section.

Figure 3.4.1A. Traffic Volumes by Time of Day



Further examination of traffic volumes across the time of day was undertaken for each vehicle class. The results of this exercise are shown in the following graphs.

Figure 3.4.1B. Personal Vehicle Volumes by Time of Day



Total traffic volumes correspond perfectly with personal vehicle volumes, as they constitute 84% of the traffic on average, and up to 88% at peak travel times.

Figure 3.4.1C. Truck Volumes by Time of Day

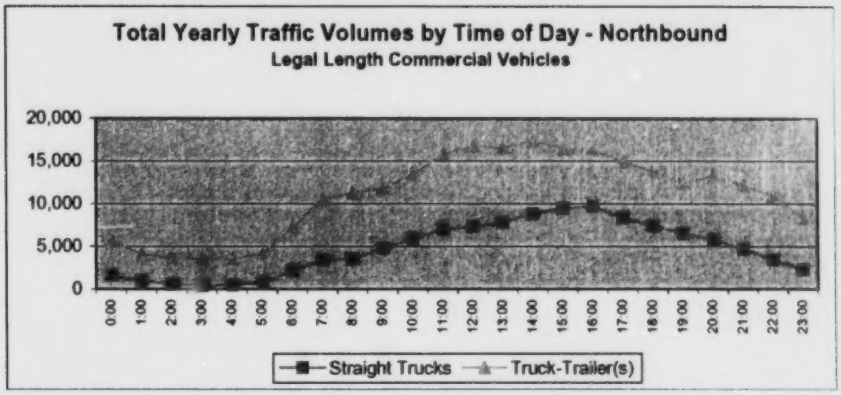
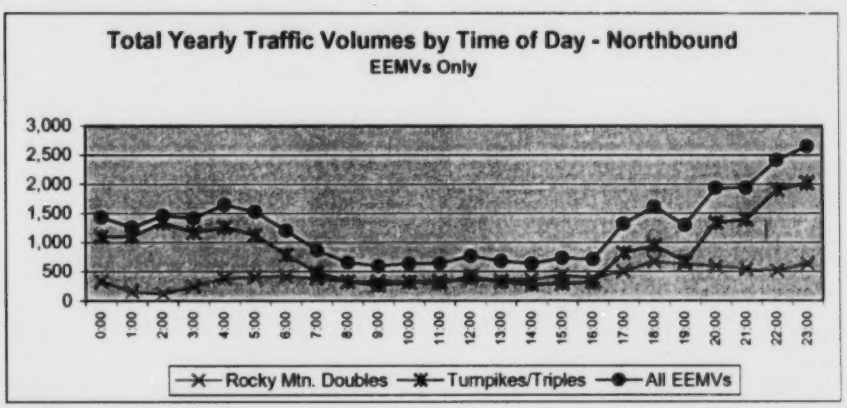


Figure 3.4.1D. EEMV Volumes by Time of Day



While all the previous, smaller vehicle classes use the road in a similar manner over the span of the day, EEMVs travel at time periods when other traffic is relatively low. The high periods of activity for these large commercial vehicles at the study location are from 20:00h – 05:00h. Drivers of these large truck combinations are minimizing their interaction with other vehicle types (i.e., avoiding the peak travel times for cars).

The results presented above were then consolidated to give a representation of the traffic mix by time of day. The results are shown below in Table 3.4.1.

Table 3.4.1B. Traffic Composition by Time of Day

Time of Day	Personal Vehicles	Straight Trucks	Truck-Trailer(s)	Rocky Mtn. Doubles	Turnpikes/ Triples	All EEMVs
00:00-01:00	70.7%	4.8%	19.0%	1.5%	4.1%	5.6%
01:00-02:00	59.6%	5.2%	25.7%	1.8%	7.6%	9.4%
02:00-03:00	49.1%	5.1%	31.8%	1.8%	12.2%	14.0%
03:00-04:00	41.4%	5.8%	38.6%	2.6%	11.6%	14.2%
04:00-05:00	45.2%	6.3%	36.8%	2.9%	8.8%	11.7%
05:00-06:00	64.2%	5.6%	24.5%	1.6%	4.1%	5.6%
06:00-07:00	78.0%	5.4%	14.4%	0.7%	1.5%	2.2%
07:00-08:00	83.9%	4.8%	10.4%	0.4%	0.6%	1.0%
08:00-09:00	83.7%	4.8%	10.7%	0.4%	0.3%	0.8%
09:00-10:00	83.7%	5.2%	10.5%	0.4%	0.3%	0.7%
10:00-11:00	84.0%	5.1%	10.3%	0.4%	0.2%	0.6%
11:00-12:00	84.2%	5.0%	10.2%	0.4%	0.2%	0.6%
12:00-13:00	83.8%	5.1%	10.5%	0.4%	0.3%	0.6%
13:00-14:00	84.7%	5.1%	9.6%	0.3%	0.3%	0.6%
14:00-15:00	85.2%	5.0%	9.3%	0.3%	0.2%	0.5%
15:00-16:00	86.5%	4.8%	8.1%	0.3%	0.3%	0.6%
16:00-17:00	87.4%	4.6%	7.5%	0.3%	0.2%	0.5%
17:00-18:00	88.4%	4.2%	6.8%	0.3%	0.3%	0.6%
18:00-19:00	86.9%	4.5%	7.7%	0.4%	0.5%	0.9%
19:00-20:00	86.0%	4.3%	8.6%	0.5%	0.6%	1.1%
20:00-21:00	84.0%	4.1%	10.1%	0.6%	1.3%	1.8%
21:00-22:00	82.5%	4.1%	10.8%	0.8%	1.9%	2.6%
22:00-23:00	79.3%	4.0%	12.7%	1.1%	2.8%	3.9%
23:00-24:00	74.7%	4.1%	15.9%	1.4%	3.9%	5.3%
Total	**84.0%**	**4.5%**	**10.4%**	**0.4%**	**0.8%**	**1.2%**

Clearly, the period between 22:00h and 07:00h is where commercial vehicles make up a significant proportion of the traffic mix, ranging from 20.7% (22:00h – 23:00h) to 58.6% (03:00h – 04:00h). This is in contrast to the remainder of the day, where commercial vehicles constitute between 11.6% and 17.5% of the vehicles using this section of highway. Another significant point of note is that EEMVs comprise less than 1% of traffic volumes during the peak demand periods for personal vehicles (from 07:00h – 19:00h).

3.4.2. Speed

Average speeds by the different vehicle classes on an hourly basis are summarized in Figures 3.4.2A through 3.4.2C.

Table 3.4.1B. Traffic Composition by Time of Day

Time of Day	Personal Vehicles	Straight Trucks	Truck-Trailer(s)	Rocky Mtn. Doubles	Turnpikes/ Triples	All EEMVs
00:00-01:00	70.7%	4.8%	19.0%	1.5%	4.1%	5.6%
01:00-02:00	59.6%	5.2%	25.7%	1.8%	7.6%	9.4%
02:00-03:00	49.1%	5.1%	31.8%	1.8%	12.2%	14.0%
03:00-04:00	41.4%	5.8%	36.6%	2.6%	11.6%	14.2%
04:00-05:00	45.2%	6.3%	36.8%	2.9%	8.8%	11.7%
05:00-06:00	64.2%	5.6%	24.5%	1.6%	4.1%	5.6%
06:00-07:00	78.0%	5.4%	14.4%	0.7%	1.5%	2.2%
07:00-08:00	83.9%	4.8%	10.4%	0.4%	0.6%	1.0%
08:00-09:00	83.7%	4.8%	10.7%	0.4%	0.3%	0.8%
09:00-10:00	83.7%	5.2%	10.5%	0.4%	0.3%	0.7%
10:00-11:00	84.0%	5.1%	10.3%	0.4%	0.2%	0.6%
11:00-12:00	84.2%	5.0%	10.2%	0.4%	0.2%	0.6%
12:00-13:00	83.8%	5.1%	10.5%	0.4%	0.3%	0.6%
13:00-14:00	84.7%	5.1%	9.6%	0.3%	0.3%	0.6%
14:00-15:00	85.2%	5.0%	9.3%	0.3%	0.2%	0.5%
15:00-16:00	86.5%	4.8%	8.1%	0.3%	0.3%	0.6%
16:00-17:00	87.4%	4.6%	7.5%	0.3%	0.2%	0.5%
17:00-18:00	88.4%	4.2%	6.8%	0.3%	0.3%	0.6%
18:00-19:00	86.9%	4.5%	7.7%	0.4%	0.5%	0.9%
19:00-20:00	86.0%	4.3%	8.6%	0.5%	0.6%	1.1%
20:00-21:00	84.0%	4.1%	10.1%	0.6%	1.3%	1.8%
21:00-22:00	82.5%	4.1%	10.8%	0.8%	1.9%	2.6%
22:00-23:00	79.3%	4.0%	12.7%	1.1%	2.8%	3.9%
23:00-24:00	74.7%	4.1%	15.9%	1.4%	3.9%	5.3%
Total	**84.0%**	**4.5%**	**10.4%**	**0.4%**	**0.8%**	**1.2%**

Clearly, the period between 22:00h and 07:00h is where commercial vehicles make up a significant proportion of the traffic mix, ranging from 20.7% (22:00h – 23:00h) to 58.6% (03:00h – 04:00h). This is in contrast to the remainder of the day, where commercial vehicles constitute between 11.6% and 17.5% of the vehicles using this section of highway. Another significant point of note is that EEMVs comprise less than 1% of traffic volumes during the peak demand periods for personal vehicles (from 07:00h – 19:00h).

3.4.2. Speed

Average speeds by the different vehicle classes on an hourly basis are summarized in Figures 3.4.2A through 3.4.2C.

Figure 3.4.2A. Personal Vehicle Speed by Time of Day

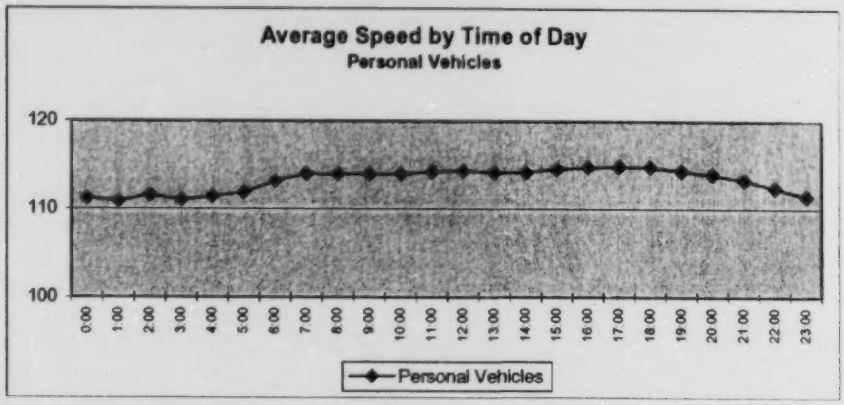


Figure 3.4.2B. Commercial Vehicle Speed by Time of Day

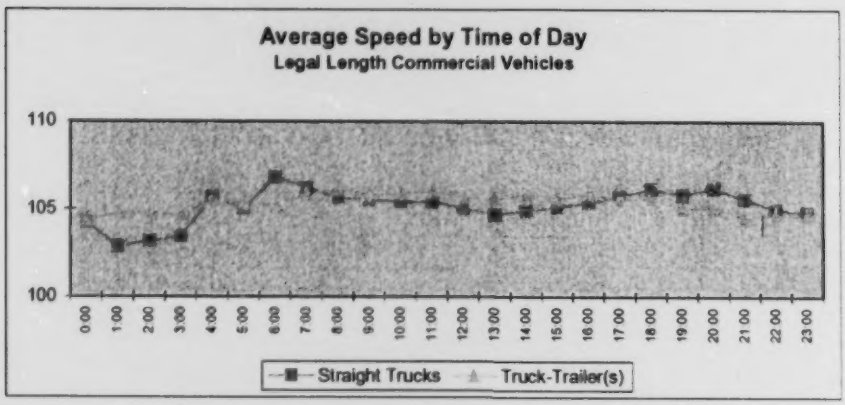
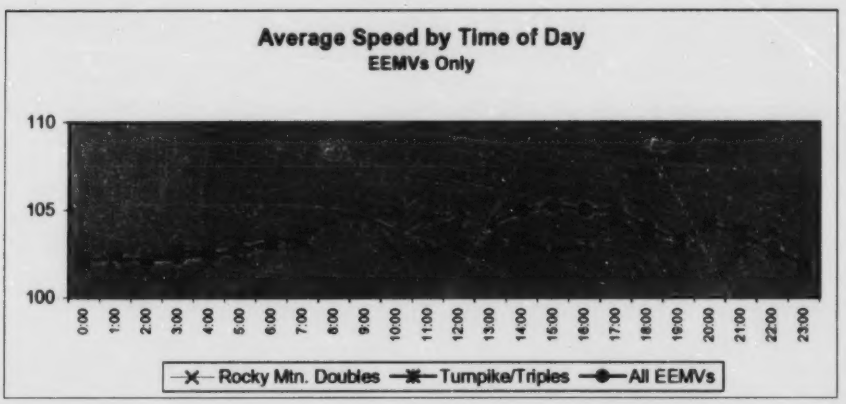


Figure 3.4.2C. EEMV Speed by Time of Day



The results of this analysis show that on average, commercial vehicle drivers travel at speeds lower than the posted speed limit, regardless of the time of day. Personal vehicle drivers however, are consistently travelling at speeds in excess of 110 kilometres per hour. As well, the average speeds of all vehicles remain relatively consistent throughout the day, however, Turnpikes and Triples Trailer drivers drive slower on average during high volume daylight hours between 10:00h and 17:00h than other times of the day.

3.4.3. Following Time

A driver's ability to maintain an appropriate following time is a function of driver behaviour, but is also related to traffic volumes and the behaviour of other drivers in the same traffic stream. With these factors in mind, time-of-day analysis was also undertaken to examine the proportion of traffic that is following the immediately preceding vehicle at less than the recommended two seconds for personal vehicle drivers, and at less than four seconds for longer commercial vehicle drivers.

Recommended following times are longer for commercial vehicles (four seconds) than for personal vehicles (two seconds). Thus, traffic by vehicle type that is following at less than the respective recommended times are shown in the following graphs. In order to show the effect that total traffic volumes may have on driver following behaviour, total hourly traffic volumes are also included in the charts.

Figure 3.4.3A. Personal Vehicles – Less Than 2 Seconds

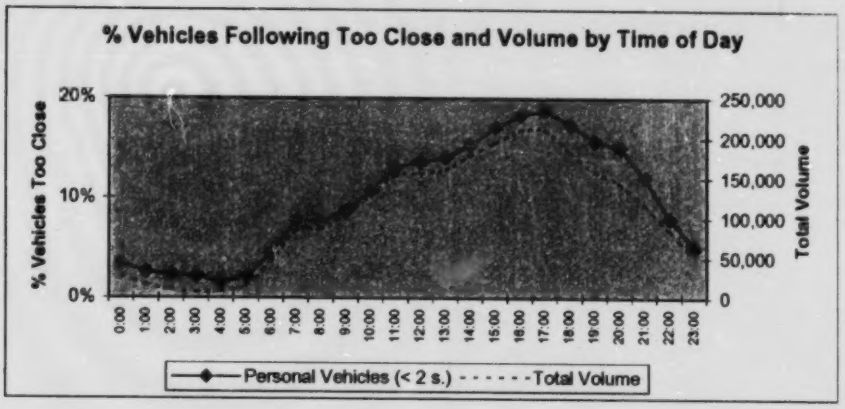
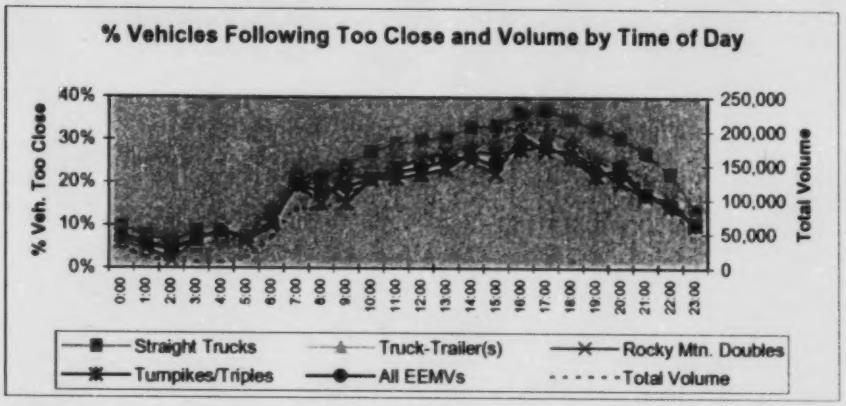


Figure 3.4.3B. Commercial Vehicles – Less Than 4 Seconds

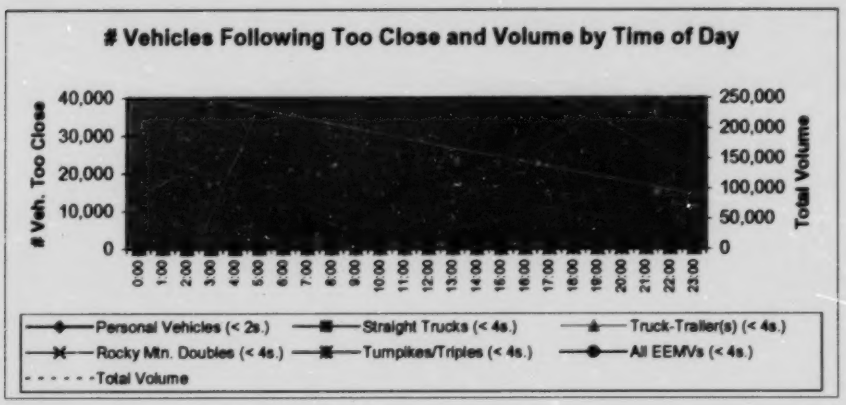


Both charts above show that there is a high degree of correlation between traffic volumes and the proportion of drivers following inappropriately. As traffic volumes increase, the percentage of drivers following at less than the recommended time increases. This behaviour is observed for drivers of all vehicle types.

However, the impact of following too closely is somewhat different. The number of personal vehicles following at less than two seconds is almost three times that of all commercial vehicles following at less than four seconds. A total of 294,000 personal vehicle drivers are following at less than two seconds (13.8% of 2,130,314). While 104,000

commercial vehicle drivers are following the preceding vehicle at less than four seconds. This is shown below in Figure 3.4.3C.

Figure 3.4.3C Number of Vehicles Following Too Close



3.5. Statistical Significance

Difference of means tests were conducted on the speed and following time averages for the five vehicle size categories to determine statistical significance. That is, to determine if each group exhibits behaviour that defines itself as being statistically significant, or different from the other groups. If groups were defined as statistically significant, conclusions drawn from comparisons between the groups would be valid. A detailed examination of the statistical significance analysis is presented in Appendix E.

The test results (see Appendix E), show that the driver behaviour differences between vehicle sizes are statistically significant at both the 95% and 99% confidence levels. Therefore, conclusions drawn from comparisons between the groups would be valid.

Discussion of the results presented in this Analysis, along with comparisons between driver behaviour of the different vehicle size classes, follows in the next section of the report, "Discussion/Conclusion".

3.6. Correlation Between Traffic Volumes and Driver Behaviour

The speed and following time at which a driver operates his or her vehicle is solely determined by the actions of the driver. However, other factors may subliminally influence how that particular driver chooses to drives. On a time-of-day basis, the shapes of curves for drivers following the preceding vehicles at less than the recommended following times (Figures 3.4.3A and 3.4.3B) closely resemble the shape of the curve for total traffic volume. Thus, an

examination was undertaken to find out if there is any possible relationship between traffic volumes and driver speed and following time behaviour.

To statistically define a relationship between two variables, a correlation coefficient is derived. A correlation coefficient is defined as:

> *"...a number between -1 and 1 which measures the degree to which two variables are linearly related. If there is perfect linear relationship with positive slope between the two variables, we have a correlation coefficient of 1; if there is positive correlation, whenever one variable has a high (low) value, so does the other. If there is a perfect linear relationship with negative slope between the two variables, we have a correlation coefficient of -1; if there is negative correlation, whenever one variable has a high (low) value, the other has a low (high) value. A correlation coefficient of 0 means that there is no linear relationship between the variables."*[14]

There are a number of statistical methods to measure correlation between variables. The choice of an appropriate correlation coefficient depends on the nature of the data itself. When examining the possible relationship between traffic volumes and either travelling speed or following time, the Spearman Rank Correlation Coefficient was used. This method is "usually calculated on occasions when it is not convenient, economic, or even possible to give actual values to variables, but only to assign a rank order to instances of each variable."[15]

The tables used to define the Spearman Rank Correlation coefficients are given in Appendix F. The results of this exercise are shown in Table 3.6.

Table 3.6 Correlations of Speed and Following Time to Volume

	Total Vehicles	Personal Vehicles	Straight Trucks	Truck-Trailer(s)	Rocky Mtn. Doubles	Turnpikes/ Triples	All EEMVs
Speed	0.973	0.932	0.319	0.513	0.859	0.452	0.838
Following Time	-0.997	-0.998	-0.999	-0.986	-0.959	-0.980	-0.974

This table shows that there is a high degree of positive correlation between traffic volumes and travelling speed for all vehicles, as well as all personal vehicles (which constitute 84% of the traffic mix). That is, as hourly traffic volumes increase, average speeds for personal vehicles also increase.

For all other vehicle types, a positive relationship exists between traffic volumes and average speed. However, the relationship is much less strong than for personal vehicles, with correlation coefficients ranging between 0.319 for straight trucks and 0.859 for Rocky Mountain Doubles.

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[14] Statistical Education through Problem Solving, UK Higher Education Funding Councils; Statistics Glossary, http://www.stats.gla.ac.uk/steps/glossary/paired_data.html, April 4, 2000.

[15] Ibid.

There is also a strong negative relationship between traffic volumes and average following times for drivers of all vehicle types. As expected, when traffic volumes increase, average following times for all vehicle types decrease (drivers are travelling closer together).

4. Summary/Conclusions

This section expands upon the results provided in the previous Analysis section. The summary of the report is presented first, followed by general findings based upon the analysis. Interpretation and discussion of the analysis is then given. Finally, conclusions that can be drawn from the study findings are given.

4.1. Summary

This report examined the speed and following time characteristics for over 2.5 million vehicles travelling northbound on Highway 2 near Leduc. This effort is intended to complement the *"Effects of Energy Efficient Motor Vehicles in Alberta"* report in order to give a more descriptive picture of driver behaviour as it relates to the size of vehicle that he/she is driving.

Data was collected and analyzed for the 1997 year, measuring each vehicle's following time, speed, and size. This information was classified into six categories based on vehicle size.

Descriptive statistics were generated for speed and following time for each vehicle category, including average, median, mode, standard deviation and variance. In general, it was found that as a vehicle's size increases, its travelling speed decreases and following time increases. Advanced statistical analysis confirmed that each of the categories is statistically significant from each other, confirming the validity of each of the vehicle length classes.

The issue of large trucks, or EEMVs is quite sensitive. This is due to their high visibility, (larger than any other vehicles), yet they constitute a very low proportion of the traffic mix, 1.2% at the study location. This report is intended to complement other literature towards giving an overall presentation of the driver behaviour of personal and commercial vehicles in the province of Alberta.

4.2. Findings

Further to the results of the analysis presented in section 3, key general findings relating to driver behaviour are summarized. These are:

General:

- The larger the vehicle, the slower it is driven.
- The larger the vehicle, the greater the amount of time at which its driver follows the preceding vehicle.
- As traffic volumes increase, the proportion of drivers following too closely increases for all vehicle types.
- There is a very strong negative relationship between total traffic volume and average following time for all vehicle types (correlation

coefficient between -0.999 and -0.959). As traffic volumes increase, average following times decrease for all vehicle types.

Personal Vehicles:

- The majority of personal vehicle drivers drive at speeds exceeding the posted speed limit.
- The total number of personal vehicle drivers following inappropriately outweighs the number of commercial drivers following too closely by a ratio of 3:1.
- There is a very strong positive relationship (0.973 correlation coefficient) between total traffic volume and personal vehicle average speed. As traffic volumes increase, personal vehicle speed also increases.

Commercial Vehicles:

- All truck types are driven, on average, below the posted speed limit.
- As truck sizes increase, fewer drivers exceed the posted speed limit.
- As truck sizes increase, fewer drivers follow the preceding vehicle at less than four seconds.
- Commercial vehicles make up the majority of traffic during early morning hours between 02:00h – 05:00h, yet they constitute only 16% of the total 24-hour traffic volumes.
- As traffic volumes increase, commercial vehicle speeds also increase, but to a much lesser degree than that observed for personal vehicles (correlation coefficient between 0.319 and 0.859).

EEMVs:

- EEMV drivers consistently travel at speeds below the posted speed limit, yet in excess of the 100 km/h EEMV speed limit.
- EEMVs are operated during times that minimize their impact on, and interaction with other vehicles (avoiding peak travel demand times for other vehicle types).

4.3. Discussion

A total of 2,537,045 vehicles were recorded on Highway 2 northbound at Leduc over the 1997 calendar year. Personal vehicles account for 84.0% of the traffic mix; straight trucks account for 4.5%; truck and trailer combinations make up 10.4%; Rocky Mountain Doubles 0.4%; and Turnpike Doubles and Triples constitute 0.8%.

4.3.1. Speed

It is clear from Table 3.2 that on average, larger vehicles travel slower than smaller vehicles. The only exception to this observation is straight trucks versus truck and trailer combinations, where the

average travelling speed for both groups is essentially equal. Similarly, the 85th percentile speed (speed at which 85% of the vehicles travel at or slower than) also decreases as vehicle size increases.

The same conclusion can be drawn for examining the proportion of each group that is travelling in violation of posted speed limits. As vehicle size increases, the proportion of vehicles that are travelling faster than 110 km/h decreases. However, as a condition of their permit, the speed of EEMVs is limited to "the lesser of 100 km/h or the posted speed limit"[16]. Table 3.2 shows that 59.7% of Rocky Mountain Doubles and 54.9% of Turnpike Doubles and Triple Trailers are in violation of this condition of the operating permit.

The reason for this situation is likely related to EEMV drivers trying not to impact the surrounding traffic. Members of the trucking industry have expressed concern that many EEMV drivers are the subjects of frustration (honking horns, gestures, etc.), from personal vehicle drivers when obeying the 100 km/h EEMV speed limit on four-lane divided highways. This is due to the fact that this condition does not permit EEMV drivers to "keep with the flow" of surrounding traffic, presenting an obstruction to other drivers.

The average operating speed for all EEMVs at the study location is 103.3 km/h, just over the permit-required speed limit (100 km/h). However, this average speed does fall within the error of measurement of ±5%, (95 to 105 km/h as measured around the 100 km/h limit). In off-peak, lower traffic volume periods, EEMVs generally adhere more closely with the 100 km/h permit requirement.

Hourly analysis undertaken in sections 3.4.2 and 3.6 shows that as traffic volumes increase, average speeds increase for all vehicle types. However, this relationship is not as strong for heavy truck drivers as it is for personal vehicle drivers.

4.3.2. Following Time

Following time is influenced in different ways than travelling speed. Sometimes, a vehicle's following time is not a result of a behaviour choice being made by the driver. This is clearly the case during nighttime driving, when traffic volumes are relatively very low (resulting in very high following times), or when a passing vehicle suddenly crosses into the same lane at a close distance (resulting in a very low following time). However, an examination of the following time behaviour across the different vehicle size classes is still worthwhile,

[16] Alberta Infrastructure, Transport Engineering; Conditions Governing the Operation of Energy Efficient Motor Vehicles in Alberta. October 20, 1999. p. 3

particularly due to the fact that the recommended following time for commercial vehicles is four seconds, while it is two seconds for personal vehicles.

The lower part of Table 3.3 shows the proportion of vehicles for each category that is following the immediately preceding vehicle within two seconds, and within four seconds. In general, as vehicle size increases, average following time (and thus following distance), also increases. For both measures (less than two seconds; less than four seconds), the percentages of vehicles that are following the preceding vehicles in less than the prescribed time decrease as vehicle size increases. This is in line with safe driving practices, since a larger vehicle takes much longer to stop due to its larger size and heavier weight.

However, time-of-day analysis undertaken in sections 3.4.3 and 3.6 shows that total traffic volume greatly influences driver following behaviour. For drivers of all vehicle types, as traffic volumes increased, the proportion of drivers following inappropriately also increased. A high degree of correlation was observed between total traffic volumes and the percentage of drivers following "too close".

Figure 3.4.3C illustrates that the total number of personal vehicles driving too closely far outweighs the total number of commercial vehicles that follow inappropriately. This is despite the fact that the recommended following time for commercial vehicles is four seconds while recommended following time for personal vehicles is two seconds.

4.4. Conclusion

The results of the analysis clearly support the hypothesis posed for this study: **"Drivers of larger vehicles travel slower and at greater following times than drivers of smaller vehicles".**

There are two major factors contributing to the higher safety performance of EEMV drivers in Alberta:

- the "*Conditions Governing the Operation of Energy Efficient Motor Vehicles in Alberta*" permit, administered by Alberta Infrastructure, Transport Engineering Branch, and;
- voluntary corporate and driver operating practices demonstrated by EEMV operators in Alberta

The EEMV permit is probably the largest contributor to the safe operation of EEMVs in Alberta. The conditions imposed upon EEMV operators (included

in Appendix A), are all designed to improve the safe operation of these longer truck combinations. These conditions are comprehensive, covering all aspects of EEMV operations, including:

- information reporting requirements;
- restricted routes over which EEMVs are allowed to operate;
- restricted times and days during which EEMVs are not permitted to operate;
- minimum equipment specifications;
- maximum equipment sizes and weights for each EEMV type;
- specific driver instructor qualifications;
- minimum driver qualifications, training and experience;
- a copy of the drivers abstract showing "*no driving-related criminal code convictions in the prior 36 months; no more than 2 moving violations in the prior 12 months; and no more than 3 moving violations in the prior 36 months*".[17]

The last condition listed above, of all the permit conditions, is probably the highest contributor to EEMV safety. This is because the absence of driving-related criminal code convictions and moving violations indicates general, overall safe driving behaviour for that particular driver. Ultimately, it is the EEMV driver who is responsible for the safe operation of the vehicle, including speed, following time, interaction with other traffic, and ensuring that all equipment is functioning properly.

Voluntary corporate and driver operating practices increase the safe operation of EEMVs by generally travelling in off-peak hours, minimizing interaction with other traffic that travels primarily during the day time.

Further, there are also financial incentives for the safe operation of EEMVs. Travelling at slower speeds and longer following times reduces the risk to the EEMV vehicle itself (which can cost upwards of a quarter million dollars). Also, fuel consumption operating costs are minimized when drivers do not travel at high speeds, particularly in excess of 100 km/h.

Given that other, smaller commercial vehicles also represent a sizeable investment, and that their fuel costs would also increase at high speeds, it can be concluded that the conditions imposed by the EEMV permit contribute the most to the higher safety levels of EEMV drivers over smaller commercial truck drivers.

This study does not indicate that EEMVs are driven less safely. To the contrary, the results demonstrate that EEMVs are driven in a safer manner than smaller commercial vehicles.

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[17] Ibid. p. 2

Appendix A EEMV Permit

Alberta
INFRASTRUCTURE

Conditions Governing the Operation of Energy Efficient Motor Vehicles in Alberta

Transport Engineering Branch
October 20, 1999

The following conditions shall apply to the operation of Energy Efficient Motor Vehicles (EEMV's), including Triple Trailer, Turnpike Double and/or Rocky Mountain Doubles. Note that these vehicles may also be referred to as LCV's or ELV's. A that a special permit is required to operate EEMV's in Alberta and that the conditions in this document are in addition to those printed on the special permit. In the case of conflict, the conditions printed on the special permit shall take precedence.

A. General Provisions

1) THAT the company and/or permittee shall, upon request of any authorized employee of Alberta Infrastructure or any peace officer, allow and assist such employee or peace officer to make any inspection, test, examination or inquiry as such member may wish to make in regard to the operation of these trailer combinations.

2) THAT the company undertake and assume full responsibility for the operation of those trailer combinations and will indemnify and save harmless Alberta Infrastructure, its officers and employees, from and against all actions, causes of actions, claims and demands which may arise as a result of these operations.

3) THAT the company shall abide by the routes, vehicle dimensions, equipment and conditions specified on, attached to or referred to by the permits as well as all applicable legislation unless specifically exempted on the permit or permit attachments.

4) THAT the company shall carry a copy of the appropriate permit in each power unit.

5) THAT, upon request, the company will supply to Transport Engineering Branch, Alberta Infrastructure, any reasonable statistics related to EEMV operations.

6) THAT the company will submit to Transport Engineering Branch, Alberta Infrastructure (phone 403-340-5189 or fax 403-340-5092) the police report number for any reportable collision involving an EEMV within one week of the date of occurrence.

7) THAT the company ensure, and be able to provide proof, that their drivers and driver trainers meet and maintain the requirements outlined in the Canadian Trucking Alliance's "Longer Combination Vehicle Driver's and/or Instructors Manual".

8) THAT the carrier is responsible to issue an annual EEMV Driver's Certificate. The Driver's Certificate is valid for a period of 12 months after the date of issue and must be in the possession of the driver at all times when operating an EEMV. Prior to issuing an EEMV Driver's Certificate, the carrier must ensure the driver meets the following qualifications:

a) Holds a valid Class 1 driver's license or equivalent.
b) Has passed a recognized air brake course or has an Air Endorsement.
c) Has a minimum of 24 months or 150,000 km of driving experience with articulated vehicles.
d) Has passed a recognized driver's medical examination within the past 24 months.
e) Has passed a Professional Driver Improvement Course within the past 48 months.
f) Has passed the Canadian Trucking Alliance's "Longer Combination Vehicles Driver Training Course".
g) The driver's abstract, dated not more than one month prior to the issue date of the Drivers Certificate, must show no driving-related criminal code convictions in the prior 36 months; no more than 2 moving violations in the prior 12 months; and no more than 3 moving violations in the prior 36 months. The date of conviction and the current date will be the dates used to determine time periods.
h) In the past 12 months the driver has been instructed on all current regulations, permit conditions and issues covering the operation of EEMV's.

9) Upon request, the company must be able to produce all documents to support the driver's qualifications.

10) Driver's Certificates issued by other jurisdictions, which meet or exceed the Alberta requirements, will be accepted as valid for the term of this agreement.

B. Instructor Qualifications

The Instructor must be certified as a Driver Trainer in their home jurisdiction and be qualified to instruct the CTA Longer Combination Vehicle Driver Training Course.

C. Equipment Requirements

1) The equipment must carry a valid CVIP decal or recognized equivalent.

2) All trucks must feature a maximum gross weight to power ratio of 160 kg per horsepower (120 kg/kW).

3) All equipment used in extended length combinations shall be equipped with brakes that meet CMVSS 121 Standards. Converter dollies do not require spring brakes.

4) The rear axle group of the power unit and all axle groups of the trailers and converters must be equipped with mud flaps or splash guards that are constructed to ensure that they remain in a rigid downward position at all times. All mud flaps or splash guards shall be mounted behind the wheels at a distance not exceeding 25.0 cm to the rear of the wheels.

5) The trailers of the combination shall be joined together by means of no-slack pintle hook(s), equipped with an air or hydraulic ram. The no-slack ram is to be incorporated in either the pintle hook or the pintle hook eye of the coupling apparatus.

D. Operational Requirements

1) Where a route falls within a city boundary, the company is responsible for obtaining permission from cities to operate extended length combinations into and out of such cities in accordance with the routes and conditions assigned by the city.

2) Any breakup or makeup of extended length combination units must be done off public roadways on private property or as directed by an authorized Alberta Infrastructure staff member or a peace officer.

3) EEMV's shall not operate during adverse weather or driving conditions (including but not limited to rain, snow, sleet, ice, smoke, fog or other conditions) which:

   a) Obscure or impede the driver's ability to drive in a safe manner, or

   b) Prevent the driver from driving with reasonable consideration for the safety of persons using the highway.

   The company is required to make a reasonable effort to determine the driving conditions on the route. Vehicles must not be dispatched when adverse conditions are known to be present on the route. Drivers encountering unexpected adverse conditions must stop at the next safe location (or as directed by an authorized Alberta Infrastructure staff member or a peace officer) and wait for the adverse conditions to abate.

4) The vehicles in a combination shall be so loaded and coupled together as to ensure that any such combination travelling on a level, smooth, paved surface will follow in the path of the towing vehicle without shifting, swerving, or swaying from side to side over 10 cm to each side of the path of the towing vehicle when it is moving in a straight line.

5) Drivers shall avoid crossing opposing lanes of traffic unless absolutely necessary.

6) Maximum speed shall be the lesser of 100 km/h or the posted speed limit.

7) This permit cannot be combined with any other permit for overwidth, overheight, overhang, or overweight.

E. Hours of Operation

Operation will be allowed 24 hours per day except in the following cases:

1) All Highways:

   Movement will **NOT** be allowed

   a) after 4:00pm on December 24th and December 31st,
   b) at anytime on December 25th, 26th and January 1st

2) On Multi-lane Highways:

   Within 40 km of the corporate boundaries of the cities of Calgary and Edmonton:

   a) Movement will **NOT** be allowed:

      i) Travelling OUTBOUND from 4:00pm to 8:00pm on Fridays and,
      ii) Travelling INBOUND from 4:00pm to 8:00pm on Sundays

b) When a statutory holiday falls on a Friday, movement will **NOT** be allowed travelling OUTBOUND from 4:00pm to 8:00pm on the preceding Thursday.

c) When a statutory holiday falls on a Monday, movement will **NOT** be allowed travelling INBOUND from 4:00pm to 8:00pm on the Monday.

3) On Two-lane Highways

a) movement will **NOT** be allowed from 4:00pm to 8:00pm on Fridays and from 4:00pm to 8:00pm on Sundays

b) When a statutory holiday falls on a Friday, movement will **NOT** be allowed from 4:00pm to 8:00pm on the preceding Thursday.

c) When a statutory holiday falls on a Monday, movement will **NOT** be allowed from 4:00pm to 8:00pm on the Monday.

d) NOTE: 3) a, b and c above do not apply to highway 35 from the southern corporate town limits of High Level to the NWT border.

e) In addition to section 3) a, b & c, movement will **NOT** be allowed on individual two-lane highways as follows:

From the Tuesday following the Labour Day Weekend (September) to the Thursday before the Victoria Day Weekend (May):

Highway	Location	Hours	Days
15	Edmonton to Jct. 21	8:00am to 7:00pm	Mon - Fri
		10:00am to 7:00pm	Saturday
		12:00pm to 7:00pm	Sunday

From the Friday before the Victoria Day Weekend (May) to the Tuesday following the Labour Day Weekend (September):

Highway	Location	Hours	Days
15	Edmonton to Jct. 21	7:00am to 11:00pm	Mon - Fri
		7:00am to 11:00pm	Saturday
		10:00am to 10:00pm	Sunday
3	AB/BC border to Jct. 22	12:00 to 5:00pm	Fri & Sat
22	Jct. 1 to Jct. 1A	1:00pm to 3:00pm	Saturday
		1:00pm to 8:00pm	Sunday

F. Statutory Holidays

(Excerpt from Public Vehicle Dimension and Weight Regulation, AR 127/98)

"statutory holiday" means:

a) New Year's Day, Family Day, Good Friday, Victoria Day, Canada Day, Labour Day, Thanksgiving Day, Remembrance Day and Christmas Day and

b) December 26, or when that day falls on a Sunday or a Monday, then December 27;

G. Turnpike Double and Triple Trailer Routes:

1) All multi-lane highways with four or more driving lanes

2) Hwy. 1A from the Calgary City Limits east to Jct. Hwy. #1

3) Hwy. #11A from Hwy. #2 east to Gaetz Avenue, Red Deer, except between 7:00 a.m. to 9:00 a.m. and 4:00 p.m. to 6:00 p.m. on weekdays.

H. Extended Length Doubles Routes:

1) All multi-lane highways with four or more driving lanes

2) The following two lane highways:

Highway	Section
1A	Calgary to Jct. 22
	Jct. 1 (Chestermere) to Calgary
2	USA boundary to Jct. 5
	Jct. 642 to Jct. 18
	Jct. 49 (West of Donnelly) to Jct. 43 (North of Grande Prairie)
2A	Jct. 2 (Leduc) to Jct. 2 (near Morningside)
3	All
4	USA boundary to Lethbridge
5	Jct. 2 to Lethbridge
12	Jct. 36 to Jct. 2
11A	Jct. 2 to Gaetz Avenue (Red Deer)
13	Jct. 2A to Camrose
14	Edmonton to Sask. border
15	Edmonton to Jct. 45 (South of Bruderheim)
16	West of Hinton to East Jasper Park Gates
17	Jct. 14 South to the Sask. border
18	Jct. 2 to Westlock
22	Jct. 1 to Jct. 1A
35	Jct. 2 to NWT border
43	Jct. 16 to BC border
49	Jct. 43 (Valleyview) to Jct. 2 (West of Donnelly)

Or additional routes as may be indicated on the permit.

SPECIFIC CONDITIONS FOR ROCKY MOUNTAIN DOUBLES

The following lists specific requirements for the equipment. Dimensions or weights, where not specifically listed, shall conform to the Alberta Public Vehicle Dimension and Weight Regulation (AR 127/98) for A, B or C trains.

PARAMETER	LIMIT	LIMIT	LIMIT
	A Converter	B Converter	C Converter
Overall Length	Max 31 m	Max 31 m	Max 31 m
Trailer One			
Length (box length)	Min 12.2 m	Min 12.2 m	Min 12.2 m
Wheelbase	Max 12.5 m	Max 14.0 m	Max 12.5 m
Hitch Offset*:			
Trailer length 12.2 - 13.7 m	Max 1.8 m	n/a	Max 1.8 m
Trailer length > 13.7 m	Max 2.8 m	n/a	Max 2.8 m
Converter Dolly			
Drawbar Length	Max 4.65 m	n/a	Max 2.0 m**
Max Number of Axles	2	n/a	1
Trailer Two – legal dimensions			
Overall Gross Vehicle Weight	Max 53,500 kg	Max 62,500 kg	Max 60,500 kg

Note: In all cases, the lead semi-trailer of the configuration must be heavier than the second trailer or semi-trailer.

Trailer two may be used as the lead semi-trailer providing the following conditions are met:

a) trailer two is heavier than trailer one and
b) only "B" or "C" converters will be allowed on any approved two lane highway.
c) "A" converters will be allowed on all turnpike/triple trailer routes.

* Tridem axle groups, because of the hitch offset requirements, are very difficult to fit into A and C train lead trailers less than 13.7 metres in length. Note that hitch offset is generally not a concern on B trains and tridem axle groups are easily accommodated.

** The 2.0 metre maximum drawbar length is applicable to "C" converters manufactured in 1993 or later, in accord with the compliance requirements to the CMVSS under the Motor Vehicle Safety Act, Canada

SPECIFIC CONDITIONS FOR TRIPLE TRAILER COMBINATIONS

The following lists specific requirements for the equipment. Dimensions or weights, where not specifically listed, shall conform to the Alberta Public Vehicle Dimension and Weight Regulation (AR 127/98) for A, B or C trains.

PARAMETER	LIMIT	LIMIT	LIMIT
	A Converter	B Converter	C Converter
Overall Length	Max 35 m	Max 35 m	Max 35 m
First Converter Dolly			
Drawbar Length	Max 4.65 m	n/a	Max 2.0 m*
Maximum number of axles	2	n/a	1
Overall Gross Vehicle Weight	53,500 kg	53,500 kg	53,500 kg

Note: In all cases, the lead semi-trailer of the configuration must be heavier than the second trailer or semi-trailer and the third trailer or semi-trailer is the lightest.

* The 2.0 metre maximum drawbar length is applicable to "C" converters manufactured in 1993 or later in accord with the compliance requirements to the CMVSS under the Motor Vehicle Safety Act, Canada.

SPECIFIC CONDITIONS FOR TURNPIKE DOUBLES

The following lists specific requirements for the equipment. Dimensions or weights, where not specifically listed, shall conform to the Alberta Public Vehicle Dimension and Weight Regulation (AR 127/98) for A, B or C trains.

PARAMETER	LIMIT	LIMIT	LIMIT
	A Converter	B Converter	C Converter
Overall Length	Max 37 m	Max 37 m	Max 37 m
Lead Semi-trailer			
Length (box length)	Min 12.2 m	Min 12.2 m	Min 12.2 m
Wheelbase	Min 9.5 m Max 12.5 m	n/a Max 14.0 m	Min 9.5 m Max 12.5 m
Hitch Offset*:			
Trailer length 12.2 m to 13.7 m	Max 1.8 m	n/a	Max 1.8 m
Trailer Length > 13.7 m	Max 2.8 m	n/a	Max 2.8 m
Converter Dolly			
Drawbar Length	Max 4.65 m	n/a	Max 2.0 m**
Maximum number of axles	2	n/a	1
Second Semi-trailer or Full Trailer			
Length	Min 12.2 m	Min 12.2 m	Min 12.2 m
Wheelbase	Min 9.5 m Max 12.5 m	Min 8.25 m Max 11.5 m	Min 9.5 m Max 12.5 m
Gross Vehicle Weight	Max 62,500 kg	Max 62,500 kg	Max 62,500 kg
MAXIMUM GROSS COMBINATION WEIGHTS			
5 Axle	41,900 kg	40,700 kg	41,900 kg
6 Axle	49,800 kg	48,600 kg	49,800 kg
7 Axle	57,700 kg	56,500 kg	57,700 kg
8 or more Axles	62,500 kg	62,500 kg	62,500 kg

Note: In all cases, the lead semi-trailer of the configuration must be heavier than the second trailer or semi-trailer.

* Tridem axle groups, because of the hitch offset requirements, are very difficult to fit into A and C train lead trailers less than 13.7 metres in length. Note that hitch offset is generally not a concern on B trains and tridem axle groups are easily accommodated.

** The 2.0 metre maximum drawbar length is applicable to "C" converters manufactured in 1993 or later, in accord with the compliance requirements to the CMVSS under the Motor Vehicle Safety Act, Canada

Appendix B Preliminary Statistical Data Results

1997 Highway 2 at Leduc Northbound
Vehicles 3.5m - 6.0m in Length (Personal Vehicles)

Day/Night Driving		Speed (km/h)	Gap (s)
Day			
Average for Inside Lane:	(531263 vehicles)	119.4334	17.7126
Average for Outside Lane:	(1120312 vehicles)	112.1250	9.3065
Average for Daytime:	**(1651575 vehicles)**	**114.4759**	**12.0105**
Night			
Average for Inside Lane:	(122896 vehicles)	118.3723	22.7302
Average for Outside Lane:	(355843 vehicles)	110.8694	15.7093
Average for Nighttime:	**(478739 vehicles)**	**112.7954**	**17.5116**

Summary Statistics for Vehicles 3.5m - 6.0m in Length (Personal

	Speed (km/h)	Gap (s)	Following Time:	Vehicles:	Percent:	Cum. %:
Average	114.0983	13.2467	Less than 2	1,490	5.0%	5.0%
Standard Deviation	7.1130	21.5625	2-4 Seconds:	3,276	10.9%	15.9%
Variance	50.5952	464.9432	Over 4 Seconds:	25,221	84.1%	100.0%
			Vehicles:	**29,987**		

1997 Highway 2 at Leduc Northbound
Vehicles 6.0m - 12.5m in Length (Straight Trucks)

Day/Night Driving		Speed (km/h)	Gap (s)
Day			
Average for Inside Lane:	(9881 vehicles)	115.4848	17.3690
Average for Outside Lane:	(80213 vehicles)	104.1350	9.2571
Average for Daytime:	**(90094 vehicles)**	**105.3798**	**10.1468**
Night			
Average for Inside Lane:	(2112 vehicles)	114.8002	23.5396
Average for Outside Lane:	(20879 vehicles)	104.4173	18.3347
Average for Nighttime:	**(22991 vehicles)**	**105.3711**	**18.8128**

Summary Statistics for Vehicles 6.0m - 12.5m in Length (Straight

	Speed (km/h)	Gap (s)	Following Time:	Vehicles:	Percent:	Cum. %:
Average	105.3780	11.9087	Less than 2	12,831	**11.3%**	11.3%
Standard Deviation	9.4421	13.9599	2-4 Seconds:	20,119	17.8%	**29.1%**
Variance	89.1531	194.8791	Over 4 Seconds:	80,135	70.9%	100.0%
			Vehicles:	**113,085**		

1997 Highway 2 at Leduc Northbound
Vehicles 12.5m - 25.0m in Length (Truck-Trailer(s))

Day/Night Driving		Speed (km/h)	Gap (s)
Day			
Average for Inside Lane:	(16521 vehicles)	113.5715	19.8740
Average for Outside Lane:	(166746 vehicles)	104.9852	10.2958
Average for Daytime:	**(183267 vehicles)**	**105.7592**	**11.1593**
Night			
Average for Inside Lane:	(4170 vehicles)	112.3398	25.0182
Average for Outside Lane:	(76222 vehicles)	104.3915	21.6190
Average for Nighttime:	**(80392 vehicles)**	**104.8038**	**21.7953**

Summary Statistics for Vehicles 12.5m - 25.0m in Length

	Speed (km/h)	Gap (s)	Following Time:	Vehicles:	Percent:	Cum. %:
Average	105.4679	14.4023	Less than 2	21,091	**8.0%**	8.0%
Standard Deviation	7.8809	16.3186	2-4 Seconds:	40,645	15.4%	**23.4%**
Variance	62.1087	266.2974	Over 4 Seconds:	201,923	76.6%	100.0%
			Vehicles:	**263,659**		

1997 Highway 2 at Leduc Northbound
Vehicles 25.0m - 31.0m in Length (Rocky Mountain Doubles)

Day/Night Driving		Speed (km/h)	Gap (s)
Day			
Average for Inside Lane:	(426 vehicles)	114.1432	20.2056
Average for Outside Lane:	(4914 vehicles)	104.6720	11.1652
Average for Daytime:	**(5340 vehicles)**	**105.4275**	**11.8864**
Night			
Average for Inside Lane:	(148 vehicles)	109.9392	26.4358
Average for Outside Lane:	(4241 vehicles)	102.4355	24.3760
Average for Nighttime:	**(4389 vehicles)**	**102.6885**	**24.4454**

Summary Statistics for Vehicles 25.0m - 31.0m in Length (Rocky Mountain Doubles):

	Speed (km/h)	Gap (s)	Following Time:	Vehicles:	Percent:	Cum. %:
Average	104.1919	17.5521	Less than 2	586	6.0%	6.0%
Standard Deviation	8.3440	18.9887	2-4 Seconds:	1,224	12.6%	18.6%
Variance	69.6216	360.5718	Over 4 Seconds:	7,919	81.4%	100.0%
			Vehicles:	**9,729**		

1997 Highway 2 at Leduc Northbound
Vehicles 31.0m - 37.0m in Length (Turnpike Dbls and Triples)

Day/Night Driving		Speed (km/h)	Gap (s)
Day			
Average for Inside Lane:	(372 vehicles)	109.5027	22.6118
Average for Outside Lane:	(5862 vehicles)	103.2088	12.2365
Average for Daytime:	**(6234 vehicles)**	**103.5844**	**12.8556**
Night			
Average for Inside Lane:	(328 vehicles)	108.4543	28.4942
Average for Outside Lane:	(13696 vehicles)	102.4179	26.9325
Average for Nighttime:	**(14024 vehicles)**	**102.5590**	**26.9690**

Summary Statistics for Vehicles 31.0m - 37.0m in Length (Turnpike Doubles and

	Speed (km/h)	Gap (s)	Following Time:	Vehicles:	Percent:	Cum. %:
Average	102.8746	22.6259	Less than 2	904	4.5%	4.5%
Standard Deviation	6.3951	22.5108	2-4 Seconds:	2,052	10.1%	14.6%
Variance	40.8976	506.7357	Over 4 Seconds:	17,302	85.4%	100.0%
			Vehicles:	**20,258**		

1997 Highway 2 at Leduc Northbound
Vehicles 25.0m - 37.0m in Length (All EEMV Configurations)

Day/Night Driving		Speed (km/h)	Gap (s)
Day			
Average for Inside Lane:	(798 vehicles)	111.9799	21.3273
Average for Outside Lane:	(10776 vehicles)	103.8760	11.7480
Average for Daytime:	**(11574 vehicles)**	**104.4348**	**12.4085**
Night			
Average for Inside Lane:	(476 vehicles)	108.9160	27.8542
Average for Outside Lane:	(17937 vehicles)	102.4220	26.3280
Average for Nighttime:	**(18413 vehicles)**	**102.5899**	**26.3675**

Summary Statistics for Vehicles 25.0m - 37.0m in Length (All EEMV Configurations):

	Speed (km/h)	Gap (s)	Following Time:	Vehicles:	Percent:	Cum. %:
Average	103.3020	20.9797	Less than 2	1,490	5.0%	5.0%
Standard Deviation	7.1130	21.5625	2-4 Seconds:	3,276	10.9%	15.9%
Variance	50.5952	464.9432	Over 4 Seconds:	25,221	84.1%	100.0%
			Vehicles:	**29,987**		

Appendix C Statistical Analysis Results and Distribution

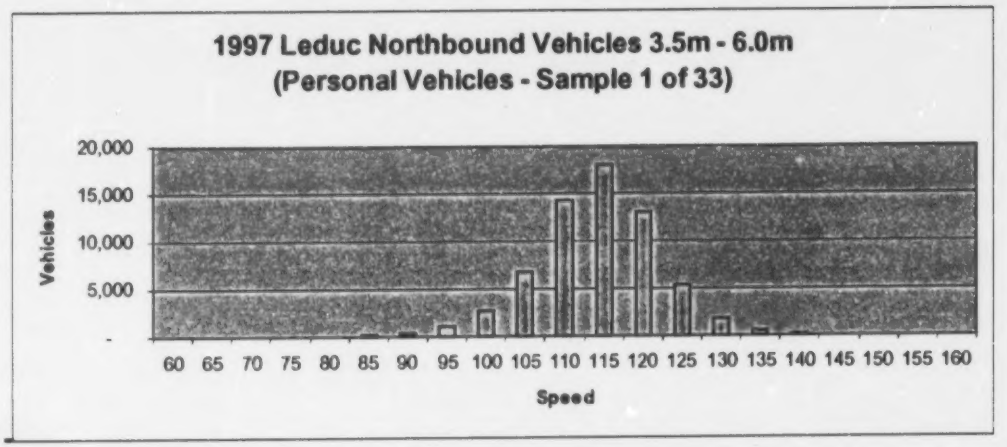
Leduc North Vehicles 3.5m - 6.0m

Gap Level	Count	Gap %
<= 2 Sec.	8,890	**13.8%**
2 - 4 Sec.	10,290	15.9%
>4 Sec.	45,375	70.3%

Speed	Count
60	3
65	10
70	21
75	22
80	70
85	166
90	436
95	1,132
100	2,734
105	6,742
110	14,252
115	18,000
120	13,009
125	5,318
130	1,724
135	581
140	199
145	81
150	31
155	20
160	4
Total	**64,555**

9,683 85th %

60.4% Speeding



Gap		*Speed (km/h)*	
Mean	13.24667493	Mean	114.0977926
Standard Error	0.062317278	Standard Error	0.032140899
Median	7.6	Median	114
Mode	1.4	Mode	114
Standard Deviation	15.8333722	Standard Deviation	8.166255485
Sample Variance	250.6956752	Sample Variance	66.68772865
Kurtosis	6.835173008	Kurtosis	1.992894402
Skewness	2.447756304	Skewness	-0.245994828
Range	99.7	Range	98
Minimum	0	Minimum	61
Maximum	99.7	Maximum	159
Sum	855139.1	Sum	7365583
Count	64555	Count	64555
Largest(9683)	24.3	Largest(9683)	122
Smallest(1)	0	Smallest(1)	61
Confidence Level(95.0%)	0.122141991	Confidence Level(95.0%)	0.062996227

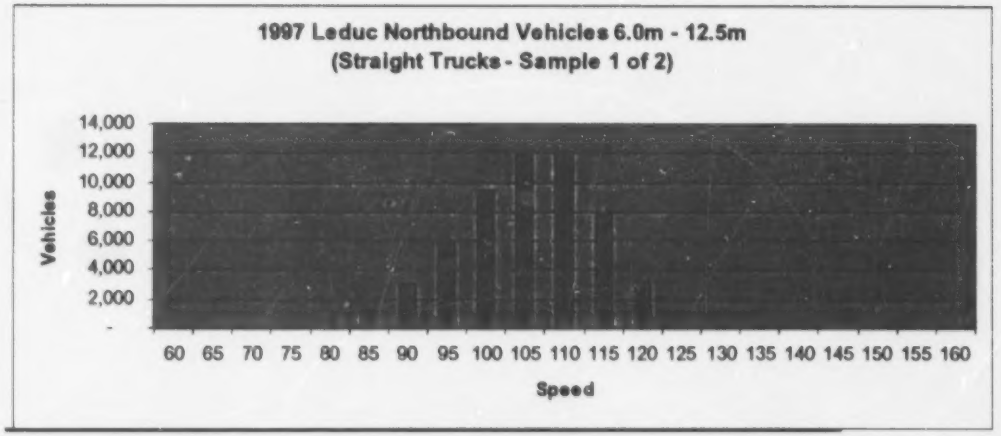
Leduc North Vehicles 6.0m - 12.5m

Gap Level	Count	Gap %
<= 2 Sec.	6,378	**11.3%**
2 - 4 Sec.	10,028	**17.7%**
>4 Sec.	40,136	71.0%

Speed	Count
60	23
65	53
70	72
75	152
80	440
85	1,196
90	2,970
95	5,773
100	9,386
105	11,968
110	12,016
115	7,807
120	3,271
125	1,017
130	267
135	67
140	32
145	15
150	7
155	8
160	2
Total	**56,542**

8,481 85th %

22.1% Speeding

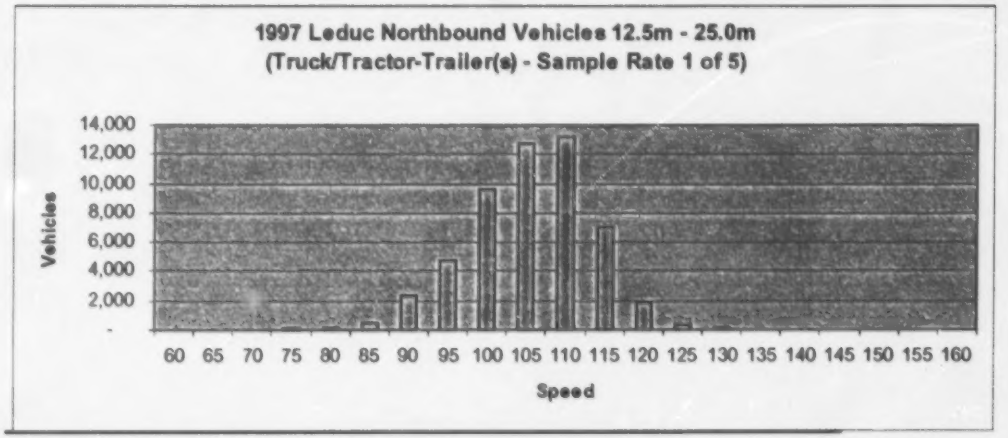


Gap		*Speed (km/h)*	
Mean	11.88479184	Mean	105.4214036
Standard Error	0.058641532	Standard Error	0.039673136
Median	7.2	Median	106
Mode	1.9	Mode	109
Standard Deviation	13.94411295	Standard Deviation	9.433701058
Sample Variance	194.4382861	Sample Variance	88.99471565
Kurtosis	9.731301485	Kurtosis	0.93374067
Skewness	2.812908454	Skewness	-0.294699076
Range	99.5	Range	99
Minimum	0	Minimum	60
Maximum	99.5	Maximum	159
Sum	671989.9	Sum	5960737
Count	56542	Count	56542
Largest(8481)	20.7	Largest(8481)	115
Smallest(1)	0	Smallest(1)	60
Confidence Level(95.0%)	0.114937788	Confidence Level(95.0%)	0.077759606

Leduc North Vehicles 12.5m - 25.0m

Gap Level	Count	Gap %
<= 2 Sec.	4,139	**7.8%**
2 - 4 Sec.	8,153	**15.5%**
>4 Sec.	40,440	76.7%

Speed	Count
60	10
65	14
70	43
75	70
80	118
85	497
90	2,365
95	4,767
100	9,583
105	12,679
110	13,162
115	7,026
120	1,905
125	383
130	82
135	15
140	8
145	2
150	1
155	2
160	-
Total	**52,732**
	7,910 85th %
	17.9% Speeding

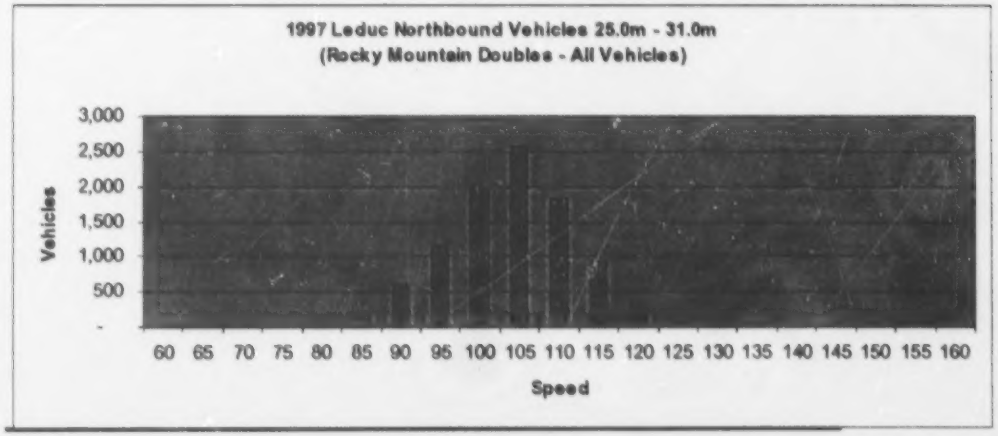


Gap		*Speed (km/h)*	
Mean	14.42488811	Mean	105.4915801
Standard Error	0.071119924	Standard Error	0.034269591
Median	8.7	Median	106
Mode	2.2	Mode	109
Standard Deviation	16.33158773	Standard Deviation	7.8694802
Sample Variance	266.7207577	Sample Variance	61.92871862
Kurtosis	6.565462481	Kurtosis	0.877262301
Skewness	2.417711757	Skewness	-0.372199004
Range	99.2	Range	96
Minimum	0.2	Minimum	60
Maximum	99.4	Maximum	156
Sum	760653.2	Sum	5562782
Count	52732	Count	52732
Largest(7910)	25.7	Largest(7910)	113
Smallest(1)	0.2	Smallest(1)	60
Confidence Level(95.0%)	0.139395518	Confidence Level(95.0%)	0.067168624

Leduc North Vehicles 25.0m - 31.0m

Gap Level	Count	Gap %
<= 2 Sec.	586	**6.0%**
2 - 4 Sec.	1,224	**12.6%**
>4 Sec.	7,919	81.4%

Speed	Count
60	1
65	1
70	11
75	11
80	41
85	120
90	601
95	1,147
100	1,992
105	2,577
110	1,816
115	946
120	316
125	85
130	31
135	18
140	6
145	3
150	4
155	2
160	-
Total	**9,729**
	1,459 85th %
(110km/h):	**14.5%** Speeding
(100km/h):	**59.7%** Speeding

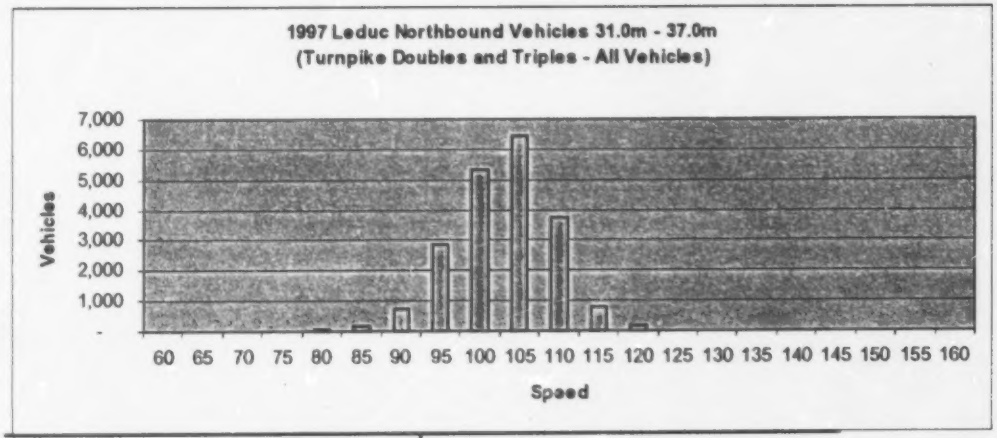


Gap		*Speed (km/h)*	
Mean	17.55211224	Mean	104.1919005
Standard Error	0.19251376	Standard Error	0.084593663
Median	10.5	Median	104
Mode	2.4	Mode	104
Standard Deviation	18.9887282	Standard Deviation	8.343954646
Sample Variance	360.5717988	Sample Variance	69.62157913
Kurtosis	3.830320922	Kurtosis	1.436122894
Skewness	1.979937923	Skewness	0.126449412
Range	99.4	Range	92
Minimum	0.3	Minimum	62
Maximum	99.7	Maximum	154
Sum	170764.5	Sum	1013683
Count	9729	Count	9729
Largest(1459)	33.9	Largest(1459)	112
Smallest(1)	0.3	Smallest(1)	62
Confidence Level(95.0%)	0.377366752	Confidence Level(95.0%)	0.165821061

Leduc North Vehicles 31.0m - 37.0m

Gap Level	Count	Gap %
<= 2 Sec.	904	**4.5%**
2 - 4 Sec.	2,052	**10.1%**
>4 Sec.	17,302	85.4%

Speed	Count
60	4
65	7
70	22
75	26
80	53
85	142
90	722
95	2,849
100	5,307
105	6,434
110	3,735
115	789
120	146
125	9
130	13
135	-
140	-
145	-
150	-
155	-
160	-
Total	**20,258**
	3,039 85th %
(110km/h):	**4.7%** Speeding
(100km/h):	**54.9%** Speeding



Gap		*Speed (km/h)*	
Mean	22.62588607	Mean	102.8745681
Standard Error	0.158158479	Standard Error	0.044931459
Median	14	Median	103
Mode	3.1	Mode	104
Standard Deviation	22.51079144	Standard Deviation	6.395121576
Sample Variance	506.7357311	Sample Variance	40.89757997
Kurtosis	1.467454213	Kurtosis	1.991082155
Skewness	1.474677846	Skewness	-0.47654052
Range	99.4	Range	69
Minimum	0.3	Minimum	61
Maximum	99.7	Maximum	130
Sum	458355.2	Sum	2084033
Count	20258	Count	20258
Largest(3039)	46.3	Largest(3039)	109
Smallest(1)	0.3	Smallest(1)	61
Confidence Level(95.0%)	0.310003164	Confidence Level(95.0%)	0.088069224

Leduc North Vehicles 25.0m - 37.0m

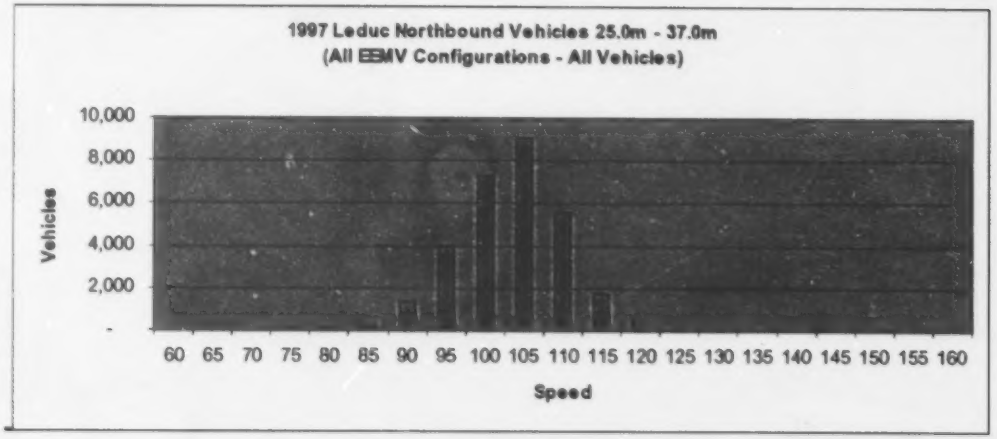
Gap Level	Count	Gap %
<= 2 Sec.	1,490	**5.0%**
2 - 4 Sec.	3,276	**10.9%**
>4 Sec.	25,221	84.1%

Speed	Count
60	5
65	8
70	33
75	37
80	94
85	262
90	1,323
95	3,996
100	7,299
105	9,011
110	5,551
115	1,735
120	462
125	94
130	44
135	18
140	6
145	3
150	4
155	2
160	-
Total	**29,987**

4,498 85th %

(110km/h): **7.9%** Speeding

(100km/h): **56.5%** Speeding



Gap		*Speed (km/h)*	
Mean	20.97974789	Mean	103.3019642
Standard Error	0.124518369	Standard Error	0.041075987
Median	12.6	Median	104
Mode	3.1	Mode	104
Standard Deviation	21.56254072	Standard Deviation	7.113028063
Sample Variance	464.9431625	Sample Variance	50.59516822
Kurtosis	2.048333589	Kurtosis	2.070492671
Skewness	1.619737547	Skewness	-0.098124495
Range	99.4	Range	93
Minimum	0.3	Minimum	61
Maximum	99.7	Maximum	154
Sum	629119.7	Sum	3097716
Count	29987	Count	29987
Largest(4498)	42.3	Largest(4498)	110
Smallest(1)	0.3	Smallest(1)	61
Confidence Level(95.0%)	0.244061349	Confidence Level(95.0%)	0.080510699

Appendix D Levels of Service

Illustration 3-5: Level of service A

Illustration 3-6: Level of service B

Illustration 3-7: Level of service C

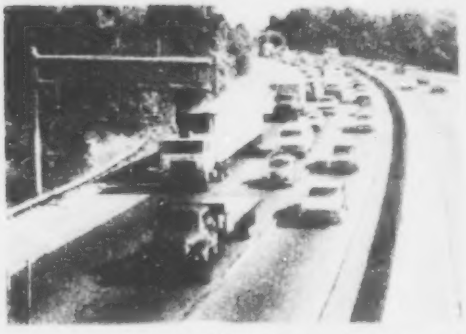


Illustration 3-8: Level of service D

Illustration 3-9: Level of service E

Illustration 3-10: Level of service F

[18] Transportation Research Board, National Research Council, Highway Capacity Manual. December, 1985. p. 3-9

Appendix E Statistical Significance

A two-sample t-test was undertaken through the functionality provided by the spreadsheet software, to determine if the groups are statistically significant from all others, within a given confidence level. That is, if the groups are found to be statistically significant from each other, then the basis for defining these groups as being distinct from each other is valid. Two confidence levels were chosen, at 95% and at 99%.

Each group is compared with all other groups to determine a t-Stat measure for that comparison, to evaluate against defined a t-critical value. The interpretation of the results is that if a t-Stat value for a comparison is less than the t-critical value, then the two groups are not statistically significant, or different. Conversely, if the t-Stat value is larger than the t-critical value, the two groups are statistically significant, or different.

For all comparisons, the t-critical value at a 95% confidence level was defined as 1.960 for a two-tailed distribution, and 1.645 for a one-tailed distribution. At 99% confidence level, t-critical for a two-tailed distribution was defined as 2.576 (two-tailed distribution), and 2.326 (one tailed distribution). Table 3.3.1 below shows the t-Stat values for all these comparisons (26 in total; 13 for speed and 13 for following time, or gap).

Table D.1. Two Sample T-Test With Unequal Variances

95% Confidence Level: t critical - two-tailed: 1.960
99% Confidence Level: t critical - two-tailed: 2.576

Speed	3.5 - 6.0m	6.0 - 12.5m	12.5 - 25.0m	25.0 - 31.0m	31.0 - 37.0m	25.0 - 37.0m
3.5 - 6.0m		169.930	183.176	109.465	203.158	206.990
6.0 - 12.5m	169.930		**1.339**	13.159	42.490	37.114
12.5 - 25.0m	183.176	**1.339**		14.240	46.312	40.932
25.0 - 31.0m	109.465	13.159	14.240		13.753	
31.0 - 37.0m	203.158	42.490	46.312	13.753		
25.0 - 37.0m	206.990	37.114	40.932			

95% Confidence Level: t critical - one-tailed: 1.645
99% Confidence Level: t critical - one-tailed: 2.326

Gap	3.5 - 6.0m	6.0 - 12.5m	12.5 - 25.0m	25.0 - 31.0m	31.0 - 37.0m	25.0 - 37.0m
3.5 - 6.0m		15.915	12.460	21.277	55.174	55.537
6.0 - 12.5m	15.915		27.556	28.161	63.677	66.080
12.5 - 25.0m	12.460	27.556		15.238	47.292	45.711
25.0 - 31.0m	21.277	28.161	15.238		20.364	
31.0 - 37.0m	55.174	63.677	47.292	20.364		
25.0 - 37.0m	55.537	66.080	45.711			

It is clear from the charts in Sections 3.2 and 3.3 that the distribution for speed is two-tailed, while the distribution for following time or gap, is one-tailed. Thus, at a 95% confidence level, the t-critical values for speed and following time are 1.960 and 1.645, respectively. At a 99% confidence level, the t-critical values are 2.576 for

speed and 2.326 for gap. An examination of the above table shows only one comparison where the t-Stat value is less than the applicable t-critical values (speed, 6.0-12.5m. vs. 12.5-25.0m). That is, in terms of speed behaviour, straight trucks and truck-trailer combinations are very similar. This might lead to the conclusion that these two groups should be aggregated into a single larger group. However, an examination of the t-Stat values for following times for the same comparison shows that these two groups are statistically different in their behaviour when it comes to following time.

The above table shows that there is justification for the basis upon which the groups were defined. That is, each group is statistically significant from all others. Therefore, conclusions drawn from comparisons between the groups are valid.

Appendix F Spearman Rank Correlation to Traffic Volumes

Speed - All Vehicles

Time			Total Volume	Average Speed	Rank Volume	Rank Speed	Di	Di^2
0:00	-	1:00	29176	109.1108	6	19	109.1108	6
1:00	-	2:00	15841	108.1251	5	20	108.1251	4
2:00	-	3:00	10362	107.4905	3	22	107.4905	3
3:00	-	4:00	8296	106.5321	1	24	106.5321	1
4:00	-	5:00	8789	107.0588	2	23	107.0588	2
5:00	-	6:00	15334	108.8233	4	21	108.8233	5
6:00	-	7:00	45641	111.346	7	18	111.346	9
7:00	-	8:00	84446	112.5513	10	15	112.5513	12
8:00	-	9:00	86239	112.5224	11	14	112.5224	11
9:00	-	10:00	105138	112.6226	12	13	112.6226	13
10:00	-	11:00	128327	112.6842	14	11	112.6842	15
11:00	-	12:00	153409	112.9364	16	9	112.9364	19
12:00	-	13:00	156243	112.9351	17	8	112.9351	18
13:00	-	14:00	160580	112.7703	19	6	112.7703	16
14:00	-	15:00	178650	112.881	20	5	112.881	17
15:00	-	16:00	194174	113.2995	22	3	113.2995	21
16:00	-	17:00	209275	113.5647	23	2	113.5647	22
17:00	-	18:00	209916	113.736	24	1	113.736	24
18:00	-	19:00	183059	113.6511	21	4	113.6511	23
19:00	-	20:00	158172	113.158	18	7	113.158	20
20:00	-	21:00	143430	112.6395	15	10	112.6395	14
21:00	-	22:00	116215	111.8941	13	12	111.8941	10
22:00	-	23:00	83572	110.7961	9	16	110.7961	8
23:00	-	24:00	52761	109.6056	8	17	109.6056	7
			2537045					62

Spearman Rank Correlation Coefficient: **0.973**

Speed – Personal Vehicles

Time			Total Volume	Average Speed	Rank Volume	Rank Speed	Di	Di^2
0:00	-	1:00	29176	111.2384	6	19	111.2384	3
1:00	-	2:00	15841	110.8922	5	20	110.8922	1
2:00	-	3:00	10362	111.5692	3	22	111.5692	6
3:00	-	4:00	8296	111.0341	1	24	111.0341	2
4:00	-	5:00	8789	111.4195	2	23	111.4195	4
5:00	-	6:00	15334	111.8711	4	21	111.8711	7
6:00	-	7:00	45641	113.1747	7	18	113.1747	9
7:00	-	8:00	84446	113.9987	10	15	113.9987	15
8:00	-	9:00	86239	113.957	11	14	113.957	12
9:00	-	10:00	105138	113.979	12	13	113.979	14
10:00	-	11:00	128327	113.9677	14	11	113.9677	13
11:00	-	12:00	153409	114.2224	16	9	114.2224	18
12:00	-	13:00	156243	114.3506	17	8	114.3506	20
13:00	-	14:00	160580	114.1585	19	6	114.1585	16
14:00	-	15:00	178650	114.1826	20	5	114.1826	17
15:00	-	16:00	194174	114.5474	22	3	114.5474	21
16:00	-	17:00	209275	114.7276	23	2	114.7276	22
17:00	-	18:00	209916	114.8174	24	1	114.8174	24
18:00	-	19:00	183059	114.7876	21	4	114.7876	23
19:00	-	20:00	158172	114.333	18	7	114.333	19
20:00	-	21:00	143430	113.8957	15	10	113.8957	11
21:00	-	22:00	116215	113.2865	13	12	113.2865	10
22:00	-	23:00	83572	112.3738	9	16	112.3738	8
23:00	-	24:00	52761	111.4589	8	17	111.4589	5
			2537045					156

Spearman Rank Correlation Coefficient: **0.932**

Speed – Straight Trucks

Time			Total Volume	Average Speed	Rank Volume	Rank Speed	Di	Di^2
0:00	-	1:00	29176	104.229	6	19	104.229	4
1:00	-	2:00	15841	102.8503	5	20	102.8503	1
2:00	-	3:00	10362	103.1395	3	22	103.1395	2
3:00	-	4:00	8296	103.4162	1	24	103.4162	3
4:00	-	5:00	8789	105.6645	2	23	105.6645	18
5:00	-	6:00	15334	105.021	4	21	105.021	9
6:00	-	7:00	45641	106.8048	7	18	106.8048	24
7:00	-	8:00	84446	106.1978	10	15	106.1978	23
8:00	-	9:00	86239	105.652	11	14	105.652	17
9:00	-	10:00	105138	105.5242	12	13	105.5242	15
10:00	-	11:00	128327	105.4231	14	11	105.4231	14
11:00	-	12:00	153409	105.4077	16	9	105.4077	13
12:00	-	13:00	156243	105.0354	17	8	105.0354	10
13:00	-	14:00	160580	104.6779	19	6	104.6779	5
14:00	-	15:00	178650	104.8733	20	5	104.8733	7
15:00	-	16:00	194174	105.1333	22	3	105.1333	11
16:00	-	17:00	209275	105.3373	23	2	105.3373	12
17:00	-	18:00	209916	105.7026	24	1	105.7026	19
18:00	-	19:00	183059	106.1283	21	4	106.1283	21
19:00	-	20:00	158172	105.7777	18	7	105.7777	20
20:00	-	21:00	143430	106.1697	15	10	106.1697	22
21:00	-	22:00	116215	105.5602	13	12	105.5602	16
22:00	-	23:00	83572	104.9741	9	16	104.9741	8
23:00	-	24:00	52761	104.7942	8	17	104.7942	6
			2537045					1566

Spearman Rank Correlation Coefficient: **0.319**

Speed – Truck-Trailer(s)

Time			Total Volume	Average Speed	Rank Volume	Rank Speed	Di	Di^2
0:00	-	1:00	29176	104.3722	6	19	104.3722	1
1:00	-	2:00	15841	104.7465	5	20	104.7465	7
2:00	-	3:00	10362	104.7447	3	22	104.7447	6
3:00	-	4:00	8296	104.6849	1	24	104.6849	4
4:00	-	5:00	8789	105.5387	2	23	105.5387	12
5:00	-	6:00	15334	105.3073	4	21	105.3073	11
6:00	-	7:00	45641	105.1752	7	18	105.1752	10
7:00	-	8:00	84446	105.8068	10	15	105.8068	18
8:00	-	9:00	86239	106.1164	11	14	106.1164	24
9:00	-	10:00	105138	105.8443	12	13	105.8443	19
10:00	-	11:00	128327	105.9005	14	11	105.9005	22
11:00	-	12:00	153409	106.0698	16	9	106.0698	23
12:00	-	13:00	156243	105.675	17	8	105.675	17
13:00	-	14:00	160580	105.5665	19	6	105.5665	14
14:00	-	15:00	178650	105.85	20	5	105.85	20
15:00	-	16:00	194174	105.628	22	3	105.628	16
16:00	-	17:00	209275	105.8748	23	2	105.8748	21
17:00	-	18:00	209916	105.562	24	1	105.562	13
18:00	-	19:00	183059	105.613	21	4	105.613	15
19:00	-	20:00	158172	105.0275	18	7	105.0275	8
20:00	-	21:00	143430	105.0737	15	10	105.0737	9
21:00	-	22:00	116215	104.4868	13	12	104.4868	2
22:00	-	23:00	83572	104.7115	9	16	104.7115	5
23:00	-	24:00	52761	104.6004	8	17	104.6004	3
			2537045					1120

Spearman Rank Correlation Coefficient: **0.513**

Speed – Rocky Mountain Doubles

Time			Total Volume	Average Speed	Rank Volume	Rank Speed	Di	Di^2
0:00	-	1:00	29176	101.9758	6	19	101.9758	5
1:00	-	2:00	15841	102.2662	5	20	102.2662	6
2:00	-	3:00	10362	101.5785	3	22	101.5785	3
3:00	-	4:00	8296	100.6721	1	24	100.6721	1
4:00	-	5:00	8789	101.9535	2	23	101.9535	4
5:00	-	6:00	15334	103.197	4	21	103.197	8
6:00	-	7:00	45641	103.4189	7	18	103.4189	10
7:00	-	8:00	84446	103.7263	10	15	103.7263	11
8:00	-	9:00	86239	104.4532	11	14	104.4532	15
9:00	-	10:00	105138	104.432	12	13	104.432	13
10:00	-	11:00	128327	104.9657	14	11	104.9657	16
11:00	-	12:00	153409	106.25	16	9	106.25	21
12:00	-	13:00	156243	106.8845	17	8	106.8845	23
13:00	-	14:00	160580	105.7784	19	6	105.7784	18
14:00	-	15:00	178650	106.1894	20	5	106.1894	20
15:00	-	16:00	194174	107.1831	22	3	107.1831	24
16:00	-	17:00	209275	106.6501	23	2	106.6501	22
17:00	-	18:00	209916	105.9339	24	1	105.9339	19
18:00	-	19:00	183059	105.1614	21	4	105.1614	17
19:00	-	20:00	158172	103.36	18	7	103.36	9
20:00	-	21:00	143430	104.4418	15	10	104.4418	14
21:00	-	22:00	116215	102.5691	13	12	102.5691	7
22:00	-	23:00	83572	103.8046	9	16	103.8046	12
23:00	-	24:00	52761	101.5016	8	17	101.5016	2
			2537045					324

Spearman Rank Correlation Coefficient: **0.859**

Speed – Turnpikes/Triples

Time			Total Volume	Average Speed	Rank Volume	Rank Speed	Di	Di^2
0:00	-	1:00	29176	102.1898	6	19	102.1898	2
1:00	-	2:00	15841	102.206	5	20	102.206	3
2:00	-	3:00	10362	102.2247	3	22	102.2247	4
3:00	-	4:00	8296	102.6504	1	24	102.6504	10
4:00	-	5:00	8789	102.5665	2	23	102.5665	8
5:00	-	6:00	15334	102.541	4	21	102.541	7
6:00	-	7:00	45641	103.1014	7	18	103.1014	16
7:00	-	8:00	84446	103.2689	10	15	103.2689	18
8:00	-	9:00	86239	104.6585	11	14	104.6585	23
9:00	-	10:00	105138	104.9071	12	13	104.9071	24
10:00	-	11:00	128327	102.373	14	11	102.373	5
11:00	-	12:00	153409	102.9233	16	9	102.9233	13
12:00	-	13:00	156243	102.7146	17	8	102.7146	12
13:00	-	14:00	160580	102.6557	19	6	102.6557	11
14:00	-	15:00	178650	103.3345	20	5	103.3345	19
15:00	-	16:00	194174	102.5119	22	3	102.5119	6
16:00	-	17:00	209275	103.0561	23	2	103.0561	14
17:00	-	18:00	209916	104.411	24	1	104.411	22
18:00	-	19:00	183059	103.2176	21	4	103.2176	17
19:00	-	20:00	158172	103.0627	18	7	103.0627	15
20:00	-	21:00	143430	104.09	15	10	104.09	21
21:00	-	22:00	116215	103.7153	13	12	103.7153	20
22:00	-	23:00	83572	102.6248	9	16	102.6248	9
23:00	-	24:00	52761	101.9022	8	17	101.9022	1
			2537045					1260

Spearman Rank Correlation Coefficient: **0.452**

Speed – All EEMVs

Time			Total Volume	Average Speed	Rank Volume	Rank Speed	Di	Di^2
0:00	-	1:00	29176	102.1402	6	19	102.1402	2
1:00	-	2:00	15841	102.2134	5	20	102.2134	5
2:00	-	3:00	10362	102.171	3	22	102.171	3
3:00	-	4:00	8296	102.3091	1	24	102.3091	6
4:00	-	5:00	8789	102.422	2	23	102.422	7
5:00	-	6:00	15334	102.7137	4	21	102.7137	8
6:00	-	7:00	45641	102.2105	7	18	102.2105	4
7:00	-	8:00	84446	103.4808	10	15	103.4808	12
8:00	-	9:00	86239	104.5554	11	14	104.5554	17
9:00	-	10:00	105138	104.645	12	13	104.645	18
10:00	-	11:00	128327	103.6734	14	11	103.6734	13
11:00	-	12:00	153409	104.7003	16	9	104.7003	20
12:00	-	13:00	156243	104.6497	17	8	104.6497	19
13:00	-	14:00	160580	104.2746	19	6	104.2746	16
14:00	-	15:00	178650	104.9511	20	5	104.9511	21
15:00	-	16:00	194174	105.3005	22	3	105.3005	24
16:00	-	17:00	209275	105.0028	23	2	105.0028	23
17:00	-	18:00	209916	104.9871	24	1	104.9871	22
18:00	-	19:00	183059	104.0248	21	4	104.0248	14
19:00	-	20:00	158172	103.2062	18	7	103.2062	10
20:00	-	21:00	143430	104.1982	15	10	104.1982	15
21:00	-	22:00	116215	103.3935	13	12	103.3935	11
22:00	-	23:00	83572	102.8777	9	16	102.8777	9
23:00	-	24:00	52761	101.8066	8	17	101.8066	1
			2537045					372

Spearman Rank Correlation Coefficient: **0.838**

Following Time – All Vehicles

Time			Total Volume	Average Gap	Rank Volume	Rank Gap	Di	Di^2
0:00	-	1:00	29176	29.2969	6	19	-13	169
1:00	-	2:00	15841	35.1397	5	21	-16	256
2:00	-	3:00	10362	37.4225	3	22	-19	361
3:00	-	4:00	8296	39.3123	1	24	-23	529
4:00	-	5:00	8789	38.2429	2	23	-21	441
5:00	-	6:00	15334	34.4275	4	20	-16	256
6:00	-	7:00	45641	22.9554	7	18	-11	121
7:00	-	8:00	84446	16.8471	10	14	-4	16
8:00	-	9:00	86239	16.9834	11	15	-4	16
9:00	-	10:00	105138	15.4233	12	12	0	0
10:00	-	11:00	128327	13.7481	14	11	3	9
11:00	-	12:00	153409	12.224	16	9	7	49
12:00	-	13:00	156243	12.1011	17	8	9	81
13:00	-	14:00	160580	11.7534	19	6	13	169
14:00	-	15:00	178650	11.0765	20	5	15	225
15:00	-	16:00	194174	10.3813	22	3	19	361
16:00	-	17:00	209275	9.7125	23	2	21	441
17:00	-	18:00	209916	9.5899	24	1	23	529
18:00	-	19:00	183059	10.5042	21	4	17	289
19:00	-	20:00	158172	11.7909	18	7	11	121
20:00	-	21:00	143430	12.5315	15	10	5	25
21:00	-	22:00	116215	15.5394	13	13	0	0
22:00	-	23:00	83572	17.9858	9	16	-7	49
23:00	-	24:00	52761	22.9519	8	17	-9	81
			2537045					4594

Spearman Rank Correlation Coefficient: **-0.997**

Following Time – Personal Vehicles

Time			Total Volume	Average Gap	Rank Volume	Rank Gap	Di	Di^2
0:00	-	1:00	29176	29.1149	6	19	-13	169
1:00	-	2:00	15841	34.7536	5	20	-15	225
2:00	-	3:00	10362	36.9917	3	22	-19	361
3:00	-	4:00	8296	40.6784	1	24	-23	529
4:00	-	5:00	8789	39.9061	2	23	-21	441
5:00	-	6:00	15334	34.8755	4	21	-17	289
6:00	-	7:00	45641	23.2902	7	18	-11	121
7:00	-	8:00	84446	17.2584	10	14	-4	16
8:00	-	9:00	86239	17.5115	11	15	-4	16
9:00	-	10:00	105138	15.9103	12	13	-1	1
10:00	-	11:00	128327	14.1514	14	11	3	9
11:00	-	12:00	153409	12.5078	16	9	7	49
12:00	-	13:00	156243	12.3387	17	8	9	81
13:00	-	14:00	160580	11.9749	19	7	12	144
14:00	-	15:00	178650	11.2734	20	5	15	225
15:00	-	16:00	194174	10.5197	22	3	19	361
16:00	-	17:00	209275	9.84	23	2	21	441
17:00	-	18:00	209916	9.7172	24	1	23	529
18:00	-	19:00	183059	10.6149	21	4	17	289
19:00	-	20:00	158172	11.8668	18	6	12	144
20:00	-	21:00	143430	12.5561	15	10	5	25
21:00	-	22:00	116215	14.639	13	12	1	1
22:00	-	23:00	83572	18.1104	9	16	-7	49
23:00	-	24:00	52761	23.0055	8	17	-9	81
			2537045					4596

Spearman Rank Correlation Coefficient: **-0.998**.

Following Time – Straight Trucks

Time			Total Volume	Average Gap	Rank Volume	Rank Gap	Di	Di^2
0:00	-	1:00	29176	29.5629	6	19	-13	169
1:00	-	2:00	15841	35.4533	5	21	-16	256
2:00	-	3:00	10362	37.275	3	22	-19	361
3:00	-	4:00	8296	39.3675	1	24	-23	529
4:00	-	5:00	8789	39.1446	2	23	-21	441
5:00	-	6:00	15334	34.4538	4	20	-16	256
6:00	-	7:00	45641	21.5829	7	18	-11	121
7:00	-	8:00	84446	15.2281	10	15	-5	25
8:00	-	9:00	86239	14.8684	11	14	-3	9
9:00	-	10:00	105138	13.0068	12	13	-1	1
10:00	-	11:00	128327	11.4416	14	11	3	9
11:00	-	12:00	153409	10.4351	16	9	7	49
12:00	-	13:00	156243	10.376	17	8	9	81
13:00	-	14:00	160580	9.9631	19	6	13	169
14:00	-	15:00	178650	9.3303	20	5	15	225
15:00	-	16:00	194174	9.094	22	3	19	361
16:00	-	17:00	209275	8.3618	23	2	21	441
17:00	-	18:00	209916	8.1359	24	1	23	529
18:00	-	19:00	183059	9.1255	21	4	17	289
19:00	-	20:00	158172	10.2286	18	7	11	121
20:00	-	21:00	143430	11.053	15	10	5	25
21:00	-	22:00	116215	12.6408	13	12	1	1
22:00	-	23:00	83572	16.0473	9	16	-7	49
23:00	-	24:00	52761	20.8772	8	17	-9	81
			2537045					4598

Spearman Rank Correlation Coefficient: **-0.999**

Following Time – Truck/Trailer(s)

Time			Total Volume	Average Gap	Rank Volume	Rank Gap	Di	Di^2
0:00	-	1:00	29176	29.6311	6	19	-13	169
1:00	-	2:00	15841	35.6234	5	21	-16	256
2:00	-	3:00	10362	37.6823	3	23	-20	400
3:00	-	4:00	8296	38.7246	1	24	-23	529
4:00	-	5:00	8789	37.4155	2	22	-20	400
5:00	-	6:00	15334	34.0589	4	20	-16	256
6:00	-	7:00	45641	21.5892	7	17	-10	100
7:00	-	8:00	84446	14.7902	10	15	-5	25
8:00	-	9:00	86239	14.4312	11	14	-3	9
9:00	-	10:00	105138	12.9067	12	12	0	0
10:00	-	11:00	128327	11.5621	14	9	5	25
11:00	-	12:00	153409	10.7618	16	6	10	100
12:00	-	13:00	156243	11.0127	17	8	9	81
13:00	-	14:00	160580	10.7804	19	7	12	144
14:00	-	15:00	178650	10.2579	20	5	15	225
15:00	-	16:00	194174	9.7175	22	3	19	361
16:00	-	17:00	209275	9.1079	23	2	21	441
17:00	-	18:00	209916	8.8141	24	1	23	529
18:00	-	19:00	183059	9.961	21	4	17	289
19:00	-	20:00	158172	11.7436	18	10	8	64
20:00	-	21:00	143430	12.8279	15	11	4	16
21:00	-	22:00	116215	14.3306	13	13	0	0
22:00	-	23:00	83572	17.6735	9	16	-7	49
23:00	-	24:00	52761	22.9762	8	18	-10	100
			2537045					4568

Spearman Rank Correlation Coefficient: **-0.986**

Following Time – Rocky Mountain Doubles

Time			Total Volume	Average Gap	Rank Volume	Rank Gap	Di	Di^2
0:00	-	1:00	29176	31.9066	6	20	-14	196
1:00	-	2:00	15841	38.4071	5	21	-16	256
2:00	-	3:00	10362	38.895	3	22	-19	361
3:00	-	4:00	8296	39.2537	1	23	-22	484
4:00	-	5:00	8789	39.832	2	24	-22	484
5:00	-	6:00	15334	30.3289	4	19	-15	225
6:00	-	7:00	45641	23.8157	7	18	-11	121
7:00	-	8:00	84446	14.8613	10	14	-4	16
8:00	-	9:00	86239	14.1973	11	13	-2	4
9:00	-	10:00	105138	11.9849	12	10	2	4
10:00	-	11:00	128327	11.8464	14	8	6	36
11:00	-	12:00	153409	10.2657	16	4	12	144
12:00	-	13:00	156243	12.4034	17	11	6	36
13:00	-	14:00	160580	11.4401	19	7	12	144
14:00	-	15:00	178650	10.9769	20	6	14	196
15:00	-	16:00	194174	10.6307	22	5	17	289
16:00	-	17:00	209275	9.1246	23	1	22	484
17:00	-	18:00	209916	10.2543	24	3	21	441
18:00	-	19:00	183059	10.1575	21	2	19	361
19:00	-	20:00	158172	11.9533	18	9	9	81
20:00	-	21:00	143430	13.7703	15	12	3	9
21:00	-	22:00	116215	15.9263	13	15	-2	4
22:00	-	23:00	83572	18.7965	9	16	-7	49
23:00	-	24:00	52761	22.8707	8	17	-9	81
			2537045					4506

Spearman Rank Correlation Coefficient: **-0.959**

Following Time – Turnpikes/Triples

Time			Total Volume	Average Gap	Rank Volume	Rank Gap	Di	Di^2
0:00	-	1:00	29176	29.8626	6	19	-13	169
1:00	-	2:00	15841	35.9466	5	22	-17	289
2:00	-	3:00	10362	38.2228	3	24	-21	441
3:00	-	4:00	8296	37.5305	1	23	-22	484
4:00	-	5:00	8789	35.6005	2	21	-19	361
5:00	-	6:00	15334	33.7035	4	20	-16	256
6:00	-	7:00	45641	23.8539	7	17	-10	100
7:00	-	8:00	84446	15.5728	10	14	-4	16
8:00	-	9:00	86239	16.1058	11	15	-4	16
9:00	-	10:00	105138	14.5383	12	12	0	0
10:00	-	11:00	128327	12.69	14	10	4	16
11:00	-	12:00	153409	10.7627	16	6	10	100
12:00	-	13:00	156243	11.0766	17	7	10	100
13:00	-	14:00	160580	12.2371	19	9	10	100
14:00	-	15:00	178650	10.1305	20	4	16	256
15:00	-	16:00	194174	9.6305	22	2	20	400
16:00	-	17:00	209275	9.7143	23	3	20	400
17:00	-	18:00	209916	9.3378	24	1	23	529
18:00	-	19:00	183059	10.7328	21	5	16	256
19:00	-	20:00	158172	12.0491	18	8	10	100
20:00	-	21:00	143430	13.1638	15	11	4	16
21:00	-	22:00	116215	15.1849	13	13	0	0
22:00	-	23:00	83572	18.6836	9	16	-7	49
23:00	-	24:00	52761	24.1874	8	18	-10	100
			2537045					4554

Spearman Rank Correlation Coefficient: **-0.980**

Following Time – All Vehicles

Time			Total Volume	Average Gap	Rank Volume	Rank Gap	Di	Di^2
0:00	-	1:00	29176	30.3367	6	19	-13	169
1:00	-	2:00	15841	36.2495	5	21	-16	256
2:00	-	3:00	10362	38.2787	3	24	-21	441
3:00	-	4:00	8296	37.8276	1	23	-22	484
4:00	-	5:00	8789	36.5978	2	22	-20	400
5:00	-	6:00	15334	32.815	4	20	-16	256
6:00	-	7:00	45641	23.8408	7	17	-10	100
7:00	-	8:00	84446	15.2588	10	14	-4	16
8:00	-	9:00	86239	15.1472	11	13	-2	4
9:00	-	10:00	105138	13.1297	12	11	1	1
10:00	-	11:00	128327	12.2669	14	10	4	16
11:00	-	12:00	153409	10.4972	16	5	11	121
12:00	-	13:00	156243	11.6928	17	7	10	100
13:00	-	14:00	160580	11.8251	19	8	11	121
14:00	-	15:00	178650	10.6098	20	6	14	196
15:00	-	16:00	194174	10.2276	22	3	19	361
16:00	-	17:00	209275	9.3909	23	1	22	484
17:00	-	18:00	209916	9.6845	24	2	22	484
18:00	-	19:00	183059	10.4939	21	4	17	289
19:00	-	20:00	158172	12.0029	18	9	9	81
20:00	-	21:00	143430	13.3504	15	12	3	9
21:00	-	22:00	116215	15.3931	13	15	-2	4
22:00	-	23:00	83572	18.7078	9	16	-7	49
23:00	-	24:00	52761	23.8731	8	18	-10	100
			2537045					4542

Spearman Rank Correlation Coefficient: **-0.974**